The Power of Air:

A Chemistry Themed and Mattel Partnership

Chemistry Themed

Toy Project 2016-2017

Date	In-Class Assignment	Homework
T 1/10	Welcome Back! Reintroduction to Project Planning Possible Building?	Gather materials and bring them in for tomorrow. This is part of your participation grade!
W 1/11	Building and Design Create Data Table Work on Practice Calculations	Continue working on design and calculations
R 1/12	Building and Design Finish Practice Calculations	Continue working on design and calculations Track will be set up for trials for tomorrow
F 1/13	Trials! (must do at least 3!) Continue Building and Design Work on Calculations	Continue working on design and calculations
M 1/16 **Martin Luther King Jr. Day**	**No School!**	
T 1/17	Trials! (must do at least 3!) Continue Building and Design Work on Calculations	Finalize design and calculations Poster and practice calculations due tomorrow!
W 1/18	Race Day! (one race per team) Videos (if done) and Posters due	

The Power of Air: A Chemistry Themed and Mattel Partnership

Word has spread about our company! Our latest potential project comes from *Mattel*. *Mattel* is a multinational toy manufacturing company that is based out of El Segundo, California and are #403 out of 500 in the Fortune 500 rankings. *Mattel* wants to partner with us to create a prototype car that is air powered. This car must be aesthetically pleasing, safe, fast, and most of all fun for children! If all of these parameters are not met, *Mattel* will not purchase the rights to manufacture the prototype we create. If this project if not successful it could financially sink the company, since we do not have any new project leads at this time. If this project succeeds, it could ultimately lead to multi-millions of dollars for the company.

The CEOs at *Mattel* and Chemistry Themed Inc have made some initial plans and decided that the air powered car must fall within the following parameters.

Parameters and Research/Development:

Size: The car must fit inside the box provided by *Mattel.* The approximate dimensions of the box are 28 cm x 15 cm x 11 cm.

Construction Materials: The actual car can be made of any materials, but should be created by your team.

Propulsion: The car must be propelled by the reaction of baking soda ($NaHCO_3$) and vinegar/acetic acid (CH_3COOH). The reaction must be contained in some sort of plastic bottle and be attached to the vehicle in some fashion. The car must go at least 6 meters in distance in the fastest amount of time in comparison with the other prototypes.

Design: The car must be aesthetically pleasing to children and must contain some sort of theme. In that theme, the car must have a name and slogan associated with it. Also, you must include a label for the box that the car will be packaged in. This box will be displayed in the store.

In order for this project to be successful for our company, we must have several prototypes created. Groups of 3-4 employees with work together to create a single prototype that abide by the above parameters. All groups must use the following reaction:

$$\_\_\_\_\_\ NaHCO_{3(s)} + \_\_\_\_\_\ HC_2H_3O_{2(aq)} \rightarrow \_\_\_\_\_\ CO_{2\,(g)} + \_\_\_\_\_\ H_2O_{(l)} + \_\_\_\_\_\ NaC_2H_3O_{2(aq)}$$

Practice Calculations, Data Table, and Required Calculations

Your group must complete the provided practice calculations prior to completing any **trial** runs. These should be turned in the day of the competition.

You and your project team must create a data table that will enable your group to answer the project questions/calculations.

Your data table should include:

a. Distance traveled
b. Mass of baking soda
c. Volume of acetic acid
d. Volume of the bottle used
e. Temperature of the room
f. Computed pressure of carbon dioxide
g. Diameter of opening of the bottle
h. Any other variables your group decides to experiment with (examples might include time allowed for the reactants to react, number of shakes, etc)

Your group will be using the formula PV=nRT to ultimately determine the amount of pressure your car can produce (too much pressure, could potentially be dangerous to children). The data table must include data recorded for at least 3 trial runs.

The questions below should be answered using the data that will give you the optimal performance of your car!

Determining the number of moles of carbon dioxide

1. What is the mass of the sodium bicarbonate used in the chemical reaction?
2. Using stoichiometry, calculate the number of moles of carbon dioxide that this mass of sodium bicarbonate could produce.
3. What is the volume in liters of acetic acid used in the chemical reaction?
4. Given that there are 0.833 moles of the acetic acid in every liter of solution, determine the number of moles of acetic acid used.
5. Using stoichiometry and the answer from number 4, determine the number of moles of carbon dioxide you could produce.
6. Given your answers to numbers 2 and 5 above, what is the actual number of moles of carbon dioxide the chemical reaction could produce?

Determining the volume

7. What is the volume of your container for the chemical reaction?
8. What is the volume of the acetic acid that will be put into the reaction vessel?
9. Knowing the answers to numbers 7 and 8, what is the maximum volume that carbon dioxide can occupy?

Determining the theoretical maximum pressure

10. Use PV=nRT to solve for the pressure that will be released by your car. **NOTE: Your pressure may not exceed 8 atm due to safety concerns.**

Presentation/Product

Your group must create a poster that contains:

1. Your theme, slogan, and box design
2. A sketch/picture ***with metric dimensions*** of your prototype
3. A Data table (this data table includes the minimal of three trial runs)
4. Calculation with work and answers (#1-10)

This poster will be turned in on the day of the Competition Day.

Competition Day

All prototypes must be created within the time line given. On the day of the competition, each group will run their car based off of the calculations that will give them optimal performance. *Mattel* has stated they would like the car to travel a total of 6 meters in the fastest amount of time.

Checklist for what to have completed by Race Day:

- Practice Questions
- Car with a theme that is designed to your group's specifications (lighter is better due to fuel transportation costs!)
- Poster that contains
    a. Theme and slogan for your car
    b. Car diagram with metric dimensions
    c. Data table with at least 3 trials
    d. Questions #1-10 for your BEST trail

Toy Car Rubric

Calculations: 15 pts (graded from poster)

a. Create a data table that includes at least three trail runs changing one operation variable. These variables could include those in the equation PV = nRT or the mass of the reactants. Groups should include distance and time in their data table in accordance with the changed operational variable.
b. All questions (#1-10) must be completed with work shown.

Racing: 15 pts (competitive speed, distance accuracy) (graded on race day)

a. Cars should travel a distance of at least 6 meters. Cars that travel at least 6 will receive 15 points for the race day. Cars going less than 6 meters or over 9 meters will be tiered compared to cars that travel 6 meters. Distances will be measured in the forward direction only. Cars that are tiered can earn no more than 10 points.
b. Points will be determined by ranking within the various tiers.
c. Racing judges may impose a point penalty of undetermined amount on the entire company, team or individuals for poor clean up, poor sportsmanship or any conduct that diminishes the integrity of the race, either on race day or on days leading up to it.
d. Starting and ending distances will be measured relative to the front-most center point of the car.

Visual appeal: 15 pts (has a cool name, theme, slogan and/or jingle, has visual appeal) (graded from poster)

a. Cars must be targeted toward children, particularly ages 8-12. Examples include boys, girls, sports enthusiasts (local teams, etc.), musical bands, TV shows, movies, etc.
b. Cars that make “too much” mess during operation relative to other cars, may be penalized.
c. Label for the box is included that is attractive and has appropriate warnings.
d. Car must be created by your team and not a prefabricated car
e. OPTIONAL: Groups may create a 30 second commercial of their project, which can contribute to the visual appeal grade.

Cost considerations: 5 pts (graded on race day)

a. Cars will be weighed and measured prior to racing. Weight does not include fuel. The lighter the car, the better, since light weight cars are more cost effective and appealing as a potential product. The size of the car matters in that it will take up physical store space. The car must fit inside the box provided.

Participation grade: 10 pts

a. Peer evaluation
b. Materials in class on Day 2 of the project
c. Using time wisely in class
d. Clean up
e. Safety while using chemicals or performing trials