

Lesson #1: Using Great Lake Maritime Facts in Dimensional Analysis

Target Subject/Grade: Chemistry Grade 10-11

Lesson Overview: In chemistry the students learn to set up math problems using dimensional analysis. This is a stepping stone to stoichiometry later in the year. The use of converting between different units and the use of large values in scientific notation are key components in a dimensional analysis lesson. The use of maritime values and facts will make this lesson unique in a chemistry setting while exposing the students some interesting Great Lakes information.

Objectives:

The students will be able to

1. Describe role of the Great Lake – St. Lawrence Seaway as a transportation artery for goods we use daily.
2. Use commodity amounts and energy efficiency values as conversions factors to incorporate maritime transport into the dimensional analysis unit.
3. Compare graphs that show the differences in greenhouse gases produced by different modes of transportation.

Michigan BENCHMARKS (for Chemistry?)

C1.2C Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.

C1.2k Analyze how science and society interact from a historical, political, economic, or social perspective.

E5.4C Analyze the empirical relationship between the emissions of carbon dioxide, atmospheric carbon dioxide levels, and the average global temperature over the past 150 years.

(The emissions of one freighter compared to train compared to trucking is relevant here and is a great connection to the information I learned at the global change teacher institute.)

References

Haen, Dean. Manager of Port of Green Bay, July 23, 2013

Hawker, J. Scott and Winebrake, James. (September 2009). GLMRI University Affiliates Meeting, Duluth, MN.
[www.glmri.org/downloads/2009Reports/affiliates Mtg/Winbrake&Hawker.pdf](http://www.glmri.org/downloads/2009Reports/affiliates%20Mtg/Winbrake&Hawker.pdf)

Research and Traffic Group. (January 2013). Environmental and

Social Impacts of Marine Transport. www.greatlakes-seaway.com/en/pdf/Impacts-Full_En.pdf

The Environmental and Social Impacts of Marine Transport in the Great Lakes-St. Lawrence Seaway Region (28 pages)

Materials?

Procedure

Focus Question: What percentage of your purchases are related to the cargo being transported on the freighters of the Great Lakes?

Show Powerpoint (provided): Interesting facts related to the Great Lakes – St. Lawrence Seaway will be provided. Calculation examples using these facts will be demonstrated using dimensional analysis. The students will have a practice calculation sheet to follow along with and will learn some new vocabulary to do conversion factors (i.e. tonnes, nautical miles, knots, BTU's).

Homework: Great Lakes Seaway Dimensional Analysis Worksheet

NOTES: Practicing Dimensional Analysis

What is a conversion factor? Two quantities with different units that are set up as an equal ratio

Examples: 2.54 cm = 1 inch, 1 mile = 5280 feet, 1.6 km = 1 mile

How do you use the conversion factors in dimensional analysis? The unit you want to cancel goes in the denominator of the ratio, the unit you are converting to must be in the numerator of the ratio.

1 inch This is used to go from centimeters to inches. Values on the bottom are divided.
2.54 cm

45.0 cm = _____ inches

45.0 cm x $\frac{1 \text{ inch}}{2.54 \text{ cm}}$ = 17.7 inches

Notice that you start with given value, you will cancel this unit by dividing by the unit equivalence (on bottom) to get to the new unit (on top). Dimensional analysis units must always cancel this way – what is on top must be in bottom of next conversion factor in order to cancel. The unit you desire should be on the top at end of your set-up.

How do you do unit conversions with rates? Rates are a little different but use the same premise.

55 mph = ___?___ km/s

55 miles x $\frac{1.6 \text{ km}}{1 \text{ mile}}$ x $\frac{1 \text{ hour} \times 1 \text{ minute}}{60 \text{ minutes} \times 60 \text{ s}}$ = **0.0244 km/s**

Yellow conversion factor converts distance units. In kilometers per second, km in the numerator, and miles are cancelled.

Green conversion factors convert time units. Because rates have time as the denominator the new unit for time will be in the denominator former units will go on top. (So if what you are cancelling is in the bottom, cancel that unit in the top and carry on.)

Sample 1: You need to transport 18,000 metric tons of coal. If you use a freighter, train, or truck – what will you need?

A freighter can carry 68,000 tonnes.

A rail car can only carry 100 tonnes.

A semi-truck can only carry 26 tonnes.



Sample 2: Compare data 18,000 tonnes vs. 30,000 tonnes in PowerPoint.

Which does not agree the rail cars or the semi-trucks?

Graph Interpretation: In 2009, what was the average household energy consumption in BTUs?

_____ BTU

How do you write this in scientific notation? _____ BTU

Sample 3: What portion of a freighter does the average household need per year?

Conversion Factors Provided:

Energy from a coal plant: _____ BTU/KWH (British Thermal Units per Kilowatt-hour)

Energy Per Pound of Coal: _____ KWH/lb

One Laker, fully loaded = _____ American tons of coal

SOLVE:



Sample 4: How many tons of coal does the average household need per year?



Sample 5: Fuel Needed on GL Seaway to move 50,000 ton from Duluth to Detroit

Sample 6: What are the Greenhouse gas emissions for the trip?