

Coal Car Calorimetry

Introduction

Trains bring coal to a power plant in one of three different types of “gondola” or “hopper” coal cars. Each of these “open” cars have its own advantages and disadvantages related to the filling and emptying. The weight/mass of the coal car is pre-determined via a certified scale and the mass is stamped on the car.



Rotary Aluminum Gondola



Aluminum Bottom Discharge



Steel Manual Hopper

Train car style	Gross weight (tons)	Carrying Weight (tons)	Removal
Rotary Aluminum Gondola	143	121	Rotary
Aluminum Bottom Discharge	143	117	Remote Door
Steel Manual Hopper	131.5	102	Manual Door

Not all coal is the same. Coal is classified into four categories: lignite, subbituminous, bituminous, and anthracite with the difference being the amount and type of carbon it contains. When combusted, each type of coal has a different enthalpy of combustion. As might be expected, the price for coal is based on the “heat content” and not just on the mass.

The average price of coal in 2017, in dollars per *short ton* (2,000 pounds) where:

- Bituminous.....\$55.60
- Lignite.....\$19.51
- Sub-bituminous....\$14.29
- Anthracite.....\$93.17

<https://www.eia.gov/energyexplained/coal/prices-and-outlook.php>

When a coal train arrives at a power plant, it is the chemist job to evaluate the coal using bomb calorimetry to determine a defined price the power plant pays to the supplier. It should go without saying that this determination is critical for both the power plant and the supplier.

Example: When the coal car under evaluation contains 121 tons of coal, this coal is sampled at 3 locations within the car, and bomb calorimetry data is collected.

1) Based on the heats of formation, calculate the heat of combustion of coal? (write the reaction and *show your work*):

2) If a 1.000 g coal sample results in an increase on temperature of 3.011 °C, **estimate (ie. no C_{cal})** the energy content of this coal in kJ/g?

3) If a 1.000 g coal sample results in an increase on temperature of 3.011 °C in a calorimeter with a C_{cal} of 1688 J/°C, **determine** the energy content of this coal in kJ/g?

4) Using the **determined** value of the heat of combustion, what type of coal is this?

ASTM class	ASTM group	MJ/kg or kJ/g
Lignite	Lignite A	<14.6
	Lignite B	14.6–19.3
Sub-bituminous	Sub-bituminous C	19.3–22.1
	Sub-bituminous B	22.1–24.4
	Sub-bituminous A	24.4–26.7
Bituminous	High volatile C	24.4–30.2
	High Volatile B	30.2–32.5
	High Volatile A	>32.5
	Medium volatile	>32.5
	Low volatile	>32.5
Anthracite	Semi-anthracite	>32.5
	Anthracite	>32.5
	Meta-anthracite	>32.5

<https://hypertextbook.com/facts/2003/JuliyaFisher.shtml>

5) How much does the entire coal car cost?