DETERMINING THE DIFFERENCES BETWEEN VARIOUS TYPES OF COAL

INTRODUCTION

Coal is a rock, usually brown or black in color, which is combustible. Coal consists of organic matter from prehistoric times, mainly the carboniferous period, which has been chemically altered by high pressures, much like the creation of oil.

The accumulation of silt, muck, and organic ingredients began in swamps and bogs millions of years ago. Tectonic shifts and movements in the earth's crust buried these areas, sometimes down enormous depths. The high pressure environment combined with the heat from the Earth's interior transformed the organic matter by altering its chemical composition. First it was transformed into peat and then peat was refined into one of the coal types: Lignite, Sub-Bituminous, Bituminous, or Anthracite.

The degree of processing results in differing qualities of coal:

LOW RANKING COALS:

PEAT - is not actually a rock yet, but no longer just organic matter, either. Peat is a major source of energy for many non-industrialized people of the world. Due to acidic conditions the organic material is prevented from decaying completely. Due to the high water content and the presence of many non-carbon materials peat is not as energy rich as true coal and is limited to use for small-scale heating.

LIGNITE (or brown coal) - is the least mature of the true coals and the most impure. It provides the least yield of energy of the true coals and burns the dirtiest. It is often crumbly, relatively moist and powdery. It has a carbon content of 25-35%. The water content is high, up to 66%. This type of coal is mainly used for large scale power generation.

SUB-BITUMINOUS - is still poorly hardened and brownish in color, but more like bituminous than lignite. It has a carbon content of 35-45%. It is still soft and brittle due to its high water content (20-30%). Sub-bituminous is used in cement manufacturing, large scale industrial processes, as well as power generation.

HIGH RANKING COALS:

BITUMINOUS - is the coal most people are used to. The black, soft, slick rock is the most common coal used around the world. The carbon content is around 60-86%, the remaining content is water, air, hydrogen, and sulfur. This type is divided into two sub-groups called steam coal and coking coal. Coking coal and steam coal are the two types of coal that is most frequently traded.

The steam coal is used as sub-bituminous coal in power generation. It has higher energy content than brown coal and contains less ash, thus making it a better fuel for coal-fired power plants.

Coking coal is a vital foundation in the metallurgical industry. High carbon content and low amounts of sulfur, phosphorous and other unwanted materials are the typical properties of coking coal.

ANTHRACITE - is usually considered to be the highest grade of coal and is actually considered to be metamorphic rock. Compared to other coals it is much harder, has a glassy luster, and is denser and blacker with few impurities. It is largely used for heating domestically as it burns with little smoke. It is almost pure carbon, 86-98% carbon with the remaining being impurities. Barely 1% of all coal mined falls into this category.

OBJECTIVES

In this experiment you will

- Measure the ppm of CO_2 given off by Lignite, Bituminous, and Anthracite when heated
- Determine the percent loss of water after heating your coal
- Observe contaminants released by coal when heated

MATERIALS (per lab group)

- 2 pulverized grams of each:
  - Peat (optional)
  - Lignite Coal
  - Bituminous Coal
  - Anthracite Coal
- Bunsen Burner
- Striker
- Tongs or Hot Hands
- Coffee Filters (one per type of coal tested)
- Ring Stand
- Large Ring
- Small Ring
- Metric Balance
- Wire Mesh
- Side Arm Flasks (one per type of coal tested, plus one for CO_2 collection)
- Lab Quest
- CO_2 Probe
- Rubber Stopper
- Plastic Tubing

PROCEDURE

1. Obtain and wear goggles.
2. Set up the apparatus as shown in the picture:

3. Obtain approximately 2 grams of each type of pulverized coal from your teacher in a labeled coffee filter; keep each type of coal in its own coffee filter.
4. Record the mass of the flask, as well as the mass of your flask plus the coal. This will be used to calculate the initial mass of your coal in the data table. Make sure to mass each flask separately, there may be variations in the mass of the flasks and will affect the measurement of water lost.
5. Place one type of coal in the flask above the Bunsen burner and place the stopper on the flask.
6. Turn on the lab quest and connect the CO_2 sensor. The CO_2 sensor should be placed in the collecting flask. Make sure the CO_2 sensor is switched to high.

7. Program the lab quest to collect data for 5 minutes. The interval does not matter because you only need initial and final measurements of CO_2.
8. Turn on gas, light the burner, and adjust the flame. Your flame should have a dark blue center cone and should not go up the sides of the flask.
9. After the coal has been heated for one minute press start on the LabQuest and begin collecting data. Record the initial level of CO_2 in your data table.
10. After 5 minutes have passed record the final level of CO_2. Remove the CO_2 sensor from the collection flask and allow the CO_2 to vent.
11. Calculate the final amount of CO_2 released by subtracting the initial measurement from the final measurement.
12. Turn off the burner, using your hot hands remove the coal flask and allow it to cool.
13. Attach a fresh flask, and add the next type of coal. Repeat steps 4-13 for each type of coal.
14. Once the coal flasks have cooled, mass the flasks. Record this mass in the data table as the mask of flask and dry coal. Calculate the mass of dry coal by subtracting the mass of the flask.
15. Calculate the percent of water for each type of coal

DATA TABLES

TABLE ONE: Percent Water Loss

Type of Coal	**Mass of Side Arm Flask**	**Mass of Side Arm Flask and Coal**	**Mass of Coal** (flask with coal – empty flask)	**Mass of Side Arm Flask and Dry Coal**	**Mass of Dry Coal**	**Percent Water in Coal**
Peat						
Lignite						
Bituminous						
Anthracite						

TABLE TWO: CO_2 Released

Type of Coal	**Initial CO_2**	**Final CO_2**	**Final CO_2 Released**
Peat			
Lignite			
Bituminous			
Anthracite			

PRE LAB QUESTIONS

1. What is the precursor to coal?

2. How is coal formed?
3. What are the four types of coal? How do they differ in quality?
4. Write two hypotheses for lab; one for the amount of CO2 released and one for the water content of each type of coal.

POST LAB QUESTIONS

1. Did you observe any differences as you burned each type of coal? List any observations you made.
2. Show your calculation for the percent water in each type of coal

$$\frac{\text{Coal} - \text{Dry Coal}}{\text{Coal}} \times 100 =$$

3. Which type of coal contained the most water? Which type contained the least? Relate this data to how the coal was formed in the earth.
4. Make two bar graphs using excel to compare the percentage of water in each type of coal as well as the amount of CO_2 released. Be sure to include all parts of a good graph.
5. What are some variables in this lab that could make the data inconsistent? How could this lab be improved?

NOTES:

- This lab gets very smelly. The lower grades of coal have many impurities, namely sulfur. If you have windows in your classroom, you may want to open them.
- If time is a constraint have lab groups divide up the types of coal and compile classroom data so that all groups have data on all types of coal.
- It is best to bring in a hammer to break up the coal. To get the best results you want to increase surface area so make sure to break it up well. The softer coals could be broken by stepping on them, however anthracite is pretty tough and the hammer works best. Put the lump of coal in a Ziploc bag, wrap with a paper towel, and strike with a hammer.

DATA TABLES

TABLE ONE: Percent Water Loss

Type of Coal	Mass of Side Arm Flask	Mass of Side Arm Flask and Coal	Mass of Coal (flask with coal – empty flask)	Mass of Side Arm Flask and Dry Coal	Mass of Dry Coal	Percent Water in Coal
Peat						
Lignite	185.20	187.25	2.05	186.35	1.15	36%
Bituminous	152.55	154.58	2.08	156.51	1.96	5.8%
Anthracite	183.00	185.07	2.07	185.00	2.00	3.4%

TABLE TWO: CO_2 Released

Type of Coal	Initial CO_2	Final CO_2	Final CO_2 Released
Peat			
Lignite	1533 ppm	100562 ppm	99029 ppm
Bituminous	1921 ppm	18271 ppm	16350 ppm
Anthracite	950 ppm	1983 ppm	1033 ppm

PRE LAB QUESTIONS

5. What is the precursor to coal? Peat
6. How is coal formed? Heat and pressure are added to peat. This condenses the molecules and removes water.

7. What are the four types of coal? How do they differ in quality? Lignite, Bituminous, Sub-bituminous, and Anthracite. They vary in carbon content (increases with quality) and inpurity/water content (decreases with quality)
8. Write two hypotheses for lab; one for the amount of CO2 released and one for the water content of each type of coal. Answers vary, should be in an if then statement.

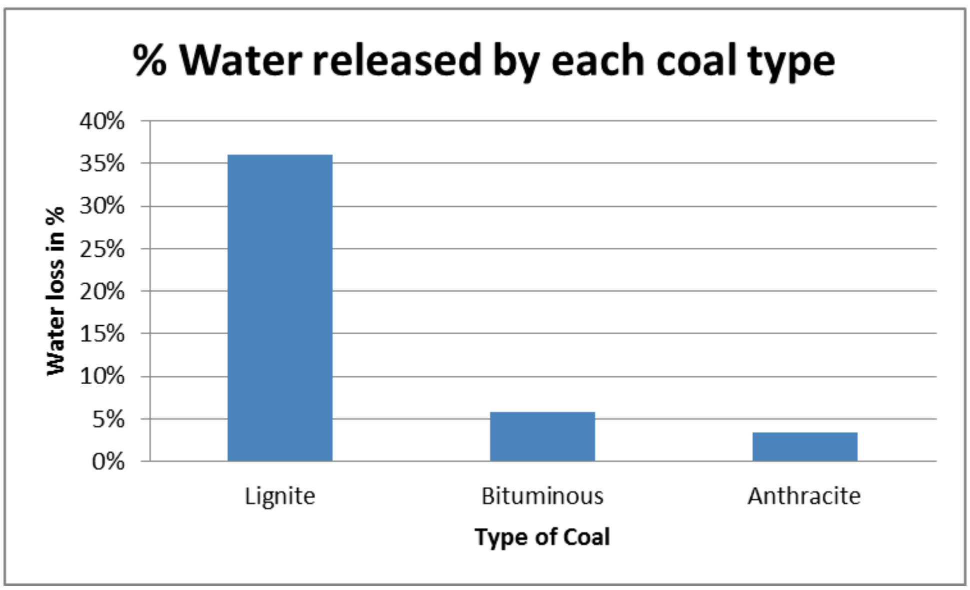
POST LAB QUESTIONS

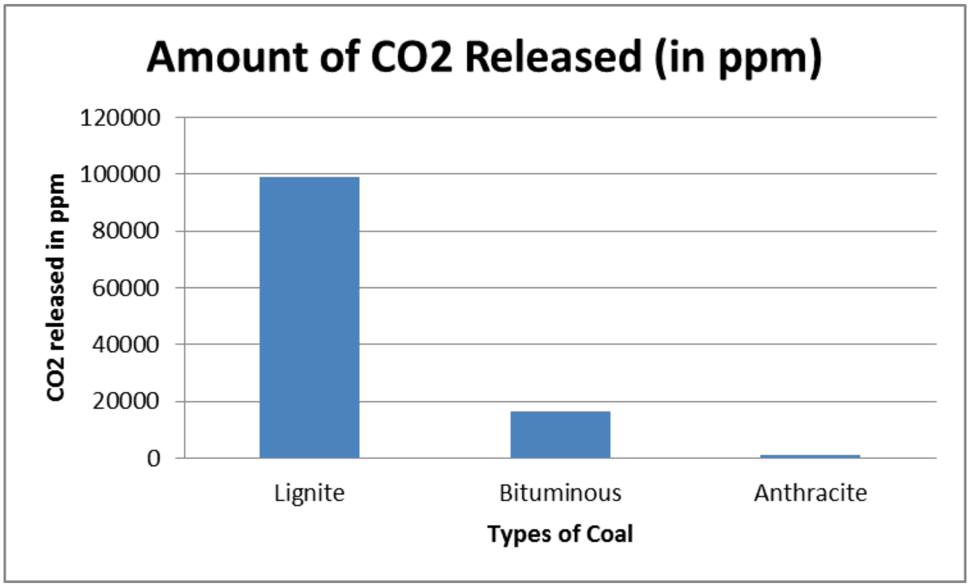
6. Did you observe any differences as you burned each type of coal? List any observations you made. Answers vary but usually include mention of condensation accumulation in the tubing for the lower grades of coal as well as strong odor or discoloration from the lower grades of coal.
7. Show your calculation for the percent water in each type of coal

$$\frac{\text{Coal} - \text{Dry Coal}}{\text{Coal}} \times 100 =$$

Lignite = 2.05 - 1.15/2.05 = 1.02/2.05 = 0.36 X 100 = 36%
Bituminous = 2.08 - 1.96/1.96 = 0.12/1.96 = 0.058 = 5.8%
Anthracite = 2.07 -2.00/2.00 = 0.07/2.00 = 0.034 = 3.4%

8. Which type of coal contained the most water? Which type contained the least? Relate this data to how the coal was formed in the earth. Lignite contained the most water and anthracite contained the least. This is because anthracite has been under more intense heat and pressure forcing more water out of the rock.
9. Make two bar graphs using excel to compare the percentage of water in each type of coal as well as the amount of CO_2 released. Be sure to include all parts of a good graph.





10. What are some variables in this lab that could make the data inconsistent? How could this lab be improved? Variables will vary but may include how well the coal was pulverized, how dry the flasks were, humidity in the room, CO_2 buildup in the room. Etc.

Free Response Coal Power

A large, coal-fired electric power plant produces 12 million kilowatt-hours of electricity each day. Assume that an input of 10,000 BTU's of heat is required to produce an output of 1 kilowatt-hour of electricity.

a. Showing all steps of your calculations, determine the number of

   1) BTU's of heat needed to generate the electricity produced by the power plant each day,

   2) pounds of coal consumed by the power plant each day, assuming that one pound yields 5,000 BTU's of heat,

   3) pounds of sulfur released by the power plant each day, assuming that the coal contains one- percent sulfur by weight.

b. The Environmental Protection Agency (EPA) standard for power plants such as this one is that no more than 1.2 pounds of sulfur be emitted per million BTU's of heat generated. Using the results in part a., determine whether the power plant meets the EPA standard.

c. Describe two ways by which a fuel-burning power plant can reduce its sulfur emissions.

d. Discuss why sulfur emissions from coal-fired power plants are considered an environmental problem and describe one negative effect on an ecosystem that has been associated with sulfur emissions.

(a) 3 POINTS MAXIMUM

1 point earned each for i, ii, and iii for correct setup and answer (units not required in answer)
1 point deducted if proper units not included within calculation in i and ii

Several different styles of equations earn credit. Some examples are:

i. $\dfrac{1.2 \times 10^{7}\ \cancel{\text{kWH}}}{\text{day}} \times \dfrac{1.0 \times 10^{4}\ \text{BTUs}}{\cancel{\text{kWH}}} = 1.2 \times 10^{11}\ \text{BTUs/day}$

$1.2 \times 10^{7}\ \cancel{\text{kWH}} \times \dfrac{1.0 \times 10^{4}\ \text{BTUs}}{\cancel{\text{kWH}}} = 1.2 \times 10^{11}\ \text{BTUs/day}$

$\dfrac{1.0 \times 10^{4}\ \text{BTUs}}{1\ \text{kWH}} = \dfrac{x}{1.2 \times 10^{7}\ \text{kWH}}\ ; \quad x = 1.2 \times 10^{11}\ \text{BTUs/day}$

12,000,000 kWH $\times$ 10,000 BTU/kWH = 120,000,000,000 BTUs/day

ii. $\dfrac{1.2 \times 10^{11}\ \cancel{\text{BTUs}}}{\text{day}} \times \dfrac{1\ \text{lb coal}}{5.0 \times 10^{3}\ \cancel{\text{BTUs}}} = 2.4 \times 10^{7}\ \text{lbs coal/day}$

$1.2 \times 10^{11}\ \cancel{\text{BTUs}} \times \dfrac{1\ \text{lb coal}}{5.0 \times 10^{3}\ \cancel{\text{BTUs}}} = 2.4 \times 10^{7}\ \text{lbs coal/day}$

$\dfrac{1\ \text{lb coal}}{5.0 \times 10^{3}\ \text{BTUs}} = \dfrac{x}{1.2 \times 10^{11}\ \text{BTUs}}\ ; \quad x = 2.4 \times 10^{7}\ \text{lbs coal/day}$

120,000,000,000 BTUs/day $\div$ 5,000 BTUs/lb coal = 24,000,000 lbs coal/day

iii. $\dfrac{2.4 \times 10^{7}\ \cancel{\text{lbs coal}}}{\text{day}} \times \dfrac{0.01\ \text{lb sulfur}}{1\ \cancel{\text{lb coal}}} = 2.4 \times 10^{5}\ \text{lbs sulfur/day}$

$2.4 \times 10^{7}\ \text{lbs coal} \times \dfrac{0.01\ \text{lb sulfur}}{1\ \text{lb coal}} = 2.4 \times 10^{5}\ \text{lbs sulfur/day}$

$\dfrac{1\ \text{lb sulfur}}{100\ \text{lbs coal}} = \dfrac{x}{2.4 \times 10^{7}\ \text{lbs coal}}\ ; \quad x = 2.4 \times 10^{5}\ \text{lbs sulfur/day}$

24,000,000 lbs of coal/day $\times$ 1% sulfur = 240,000 lbs of sulfur/day

(b) 2 POINTS MAXIMUM

1 point earned for an appropriate method that shows how the conclusion was reached (units of measurement not required)

$$\frac{1.2 \times 10^{11}\ \cancel{\text{BTUs}}}{\text{day}} \times \frac{1.2\ \text{lbs}}{1.0 \times 10^{6}\ \cancel{\text{BTUs}}} = 1.44 \times 10^{5}\ \text{lbs sulfur/day maximum allowable release}$$

$$120{,}000{,}000{,}000\ \cancel{\text{BTUs}} \times \frac{1.2\ \text{lbs}}{1{,}000{,}000\ \cancel{\text{BTUs}}} = 144{,}000\ \text{lbs sulfur/day maximum allowable release}$$

$$\frac{2.4 \times 10^{5}\ \text{lbs sulfur}}{1.2 \times 10^{11}\ \cancel{\text{BTUs}}} \times \frac{1.0 \times 10^{6}\ \cancel{\text{BTUs}}}{1\ \text{million BTUs}} = 2\ \text{lbs sulfur/million BTUs actually released}$$

$$\frac{2.4 \times 10^{5}\ \text{lbs sulfur}}{1.2 \times 10^{11}\ \text{BTUs}} = \frac{x}{1.0 \times 10^{6}\ \text{BTUs}} \;;\quad x = 2\ \text{lbs sulfur per million BTUs}$$

$$1{,}000{,}000\ \cancel{\text{BTUs}} \times \frac{1\ \text{lb coal}}{5{,}000\ \cancel{\text{BTUs}}} = 200\ \text{lbs coal}$$

$$200\ \cancel{\text{lbs coal}} \times \frac{1\ \text{lb sulfur}}{100\ \cancel{\text{lbs coal}}} = 2\ \text{lbs sulfur/million BTUs}$$

1 point earned for reaching a conclusion that is consistent with the method used to compare the permissible sulfur level with the sulfur level determined in (a) iii or with the 1.2 lbs permitted by the EPA. (Conclusions that are incorrect due to mathematical errors, but are based on valid calculations, earn the point.)

The power plant is NOT in compliance, because it releases

- 2 lbs of sulfur per million BTUs instead of the 1.2 lbs per million BTUs as the EPA allows

OR

- 2.4×10^{5} lbs of sulfur/day when the limit is 1.44×10^{5} lbs/day

(c) 3 POINTS MAXIMUM

1 point earned for EACH method DESCRIBED (two methods are requested)

Methods are associated to the point in the process where the reduction may occur. Simply listed, these methods, which are NOT considered descriptions, include:

<u>Input</u>, where 1) using low-sulfur coal; 2) "washing" the coal; 3) coal gasification; and 4) using alternative combustible fuels are identified in textbooks.

Example of description: "Coal can be chemically treated to reduce its sulfur content."

<u>Combustion</u>, where 1) fluidized-gas combustion and 2) burning low-sulfur coal are identified in textbooks.

Example of description: "Plant can add limestone to the coal when it is burned."

<u>Output</u>, where 1) using scrubbers and 2) treatment with NH_3 are identified in textbooks.

Example of description: "Plant can install scrubbers in its smokestacks."

<u>Other</u>, where 1) conservation education is common and 2) source reduction, which includes reducing the electricity generated by the plant and/or increasing the efficiency of the plant, are identified in textbooks

Example of description: "Plant can develop conservation education programs to reduce electricity demand."

1 point earned for elaboration on either, but not both, methods. Elaborations must include a detailed description of how the described method is related to the sulfur emissions.

<u>Elaboration point examples:</u>

Discussion of fluidized-bed combustion: crushed limestone is introduced into the crushed coal, which is then burned. The calcium in the limestone reacts with the sulfur in the coal to produce calcium sulfite ($CaSO_3$), calcium sulfate ($CaSO_4$), or gypsum ($CaSO_4$).

Discussion of wet vs dry scrubbing: Injected crushed limestone or lime slurry into emission (wet scrubbing); Injected sodium carbonate or bicarbonate into emission (dry scrubbing)

Discussion of source reduction: the plant reduced the amount of electricity it generates by reducing it capacity, thereby burning less coal, or by increasing the efficiency of the plant to increase the amount of electricity generated, which reduces the absolute amount of its emissions.

(d) 3 POINTS MAXIMUM

1 point for DISCUSSION of the problem (must include either <u>how</u> or <u>why</u> the emissions are a problem)

<u>Two commonly recognized problems</u>: 1) increasing acidification of ecosystems (how or why), and 2) increased oxides of sulfur aerosols leading to regional cooling, smog, or respiratory distress (how or why).

1 point possibly earned for elaboration

<u>Elaboration point examples:</u>

- Formation of H_2SO_4 from SO_2 ($SO_2 \Rightarrow SO_3 + H_2O \rightarrow H_2SO_4$)
- Wet *vs.* dry deposition
  - SO_2 and SO_3 wind transport and reaction with water in ecosystems is dry
  - H_2SO_4 in precipitation is wet
- increased amounts of sulfur oxide aerosols absorb incoming UV-radiation, thereby cooling the lower atmosphere
- increased amounts of sulfur oxide aerosols irritate mucous linings in respiratory system (aerosols NOT disease-causing agents)

1 point earned for description of negative effect

<u>Possible Negative Effects</u>:

- Increased solubility of toxic metals as a result of the increased acidity in the ecosystem
- Increased leaching of soil nutrients
- Reduced buffering capacity of soil
- Fisheries kills as a result of changes in pH of aquatic ecosystems (In addition to deaths of adults, survival of eggs, young, fry, fingerlings are reduced.)
- Fisheries kills as a result of increase of toxic chemicals in aquatic ecosystems due to changes in pH
- Tree deaths as a result of changes in pH of soil ecosystems
- Tree deaths as a result of increase of toxic chemicals in soil ecosystems due to changes in pH
- Change in species composition due differences in range of tolerance for pH.
- Increase in disease-susceptibility of plants
- Disruption (simplification) of food webs as a result of the decline or loss of pH-sensitive organisms at various trophic levels
- Increased solubility of methyl mercury
- Interferes with calcium deposition and/or uptake as a result of the increased acidity in the ecosystem
- Changes in vegetation, including crops, due to changes in regional climate
- Changes in fauna distribution due to changes in regional climate
- Changes in fauna distribution due to changes in vegetation
- Changes in precipitation patterns due to changes in regional climate

1 point possible for elaboration (must demonstrate a more detailed understanding of the negative effect

1 Q1

ENVIRONMENTAL SCIENCE
SECTION II
Time—90 minutes
4 Questions

Directions: Answer all four questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers on the pages following the questions in this booklet, NOT on the green insert. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples.

1. A large, coal-fired electric power plant produces 12 million kilowatt-hours of electricity each day. Assume that an input of 10,000 BTU's of heat is required to produce an output of 1 kilowatt-hour of electricity.

   (a) Showing all steps in your calculations, determine the number of

   (i) BTU's of heat needed to generate the electricity produced by the power plant each day,

   (ii) pounds of coal consumed by the power plant each day, assuming that one pound of coal yields 5,000 BTU's of heat,

   (iii) pounds of sulfur released by the power plant each day, assuming that the coal contains one percent sulfur by weight.

   (b) The Environmental Protection Agency (EPA) standard for power plants such as this one is that no more than 1.2 pounds of sulfur be emitted per million BTU's of heat generated. Using the results in part (a), determine whether the power plant meets the EPA standard.

   (c) Describe two ways by which a fuel-burning electric power plant can reduce its sulfur emissions.

   (d) Discuss why sulfur emissions from coal-fired power plants are considered an environmental problem and describe one negative effect on an ecosystem that has been associated with sulfur emissions.

a.) (i.) 12 million kwh / day
10,000 BTU's = 1 kwh
12 million kwh x 10,000 BTU's = 120,000,000,000 BTU's needed to produce 12 million kwh of electricity each day

(ii) 1 lb coal = 5,000 BTU's
needed BTU's = 120,000,000,000; divided by 5,000 BTU's in one pound of coal will equal pounds of coal consumed
120,000,000,000 BTU'S ÷ 5000 BTU's/pound = 24000000 lbs

(iii) Pounds of coal = 24,000,000
multiply by 1% (.01) 24,000,000 lbs coal X .01 = 240000 lbs Sulfu

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

b.) There are 120,000,000,000 BTU'S used each day
The standard for sulfur = 1.2 lbs/million BTU'S
120,000 million BTU'S x 1.2 lbs of sulfur
= 144,000 lbs of sulfur is allowed by EPA.
The plant uses 240,000 lbs of sulfur, so it is over the limit by 96,000 lbs of sulfur.

c.) A power plant can reduce its emissions by reducing the total amount of fuel (coal) that it burns. This fuel reduction may call for alternative fuel sources, such as nuclear or biomass.

It can also use scrubbers in the smokestacks to reduce sulfur emissions. Scrubbers contain chemicals that are used to combine with the sulfur and form a precipitate. This sludge or precipitate will not be allowed to be emitted into the atmosphere. An example of a scrubber is a lime scrubber. It uses a lime spray to react with the sulfur to form a precipitate and reduce sulfur emissions into the atmosphere.

d.) When sulfur is released into the atmosphere it combines with water vapor and other chemicals to form acid precipitation. Acid rain that falls into an aquatic ecosystem changes the pH of the water. It causes a lower (or more acidic) pH. This change effects the amount of nutrients and minerals that the soil can hold. The H^+ ions won't

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

allow room for the heavy metals to connect to soil particles. This reduces the amount of nutrients that algae can absorb and decreases their population. A decrease in aquatic plants means less food and oxygen for aquatic animals. Acid rain, therefore, eventually leads to a decrease in biodiversity of aquatic ecosystems.

1R1

ENVIRONMENTAL SCIENCE
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   (b) The Environmental Protection Agency (EPA) standard for power plants such as this one is that no more than 1.2 pounds of sulfur be emitted per million BTU's of heat generated. Using the results in part (a), determine whether the power plant meets the EPA standard.

   (c) Describe two ways by which a fuel-burning electric power plant can reduce its sulfur emissions.

   (d) Discuss why sulfur emissions from coal-fired power plants are considered an environmental problem and describe one negative effect on an ecosystem that has been associated with sulfur emissions.

(a)(i) 12,000,000 kilowatt-hours × 10,000 BTU = 120,000,000,000 BTU
(ii) 120,000,000,000 BTU ÷ 5,000 BTU = 24,000,000 pounds of coal
(iii) 24,000,000 pounds of coal × 1% = 240000 pounds of sulfur
(b) $\frac{240,000 \text{ pounds of sulfur}}{120,000,000,000 \text{ BTU}} = \frac{x}{1,000,000 \text{ BTU}}$ x = 2 pounds of sulfur.
This power plant does not meet the EPA standards because it emits 2 pounds of sulfur per million BTU's of heat generated.
(c) One way a fuel-burning electric power plant can reduce its sulfur emissions is to switch to a fuel source which contains less sulfur. This can also be a negative thing because the source with less sulfur might put out less

1R2

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

energy. The power plant might also use different techniques ~~stro~~, such as smoke stack scrubbers, chemical sprays that weigh down or neutrilize pollutants, cyclones, which spin the waste pushing the pollutants against the side of the smoke stack, or electrostatic filters, which use electrical charges to trap ionic particles in smoke stacks, to reduce the amount of sulfur that is released from the plant.

(d) Sulfur emissions can cause ~~many~~ environmental damage. The sulfur can get into a water supply making it undrinkable. It could also have a negative effect on the wildlife and agriculture of an area.

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a) (i) we know that for every kilowatt-hour of electricity produced, 10,000 BTU's of heat are required. Therefore, if 12 million kilowatt-hours of electricity are produced, the total BTU's of heat will be (10,000 x 12,000,000). The total BTU's needed each day are 120,000,000,000 BTU's of heat.

(ii) To find the amount of coal needed, we divide the total BTU's of heat by 5,000. This equals 24,000,000 pounds of coal

(iii) The total amount of sulfur released equals one percent of the total amount of coal.

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Question 1

Sample Q – Score 10

This is a good example of a student who scored 10 points on question 1. The calculations in parts (a) and (b) are clearly shown. The student was able to clearly and accurately describe and elaborate of methods of reducing sulfur emissions from power plants, as well and discuss an environmental problem and specific negative effect associated with sulfur emissions.

Sample R – Score 7

This paper is a good example of a student who did very well on the calculation portion of the question, and was able to adequately described two methods of reducing sulfur emissions. The student did not, however, discuss a valid environmental problem associated with sulfur emissions.

Sample S – Score 7

This paper is a typical example of a student who did not clearly carry units through the calculations. The student received two of three points in part (a), but no points in part (b) as there was no indication of how the answer in part (b) was reached. The student received one point in part (c) and one point in part (d).