SOLAR ENERGY AS A RESOURCE

NAME________________________________ SCHOOL ______________________________

DATE STARTED______________________ DATE COMPLETED ___________________

PREREQUISITE: Algebra 1 Part A—The Language of Mathematics course or equivalent basic algebra abilities.

HOW TO DO THIS COURSE: Do the steps one at a time, in order. When you finish a step, put your initials and the date on the sign-off line on the right. A split line means to get a pass (and an initial) from another student or your Academic Supervisor if it says that. Essays are turned in to the Academic Supervisor.

PURPOSE: Understand enough about the basic principles and methods of solar energy collection to be able to explore the decisions individuals and society will have to make about its use, and then utilize the basics to build a working solar still.

ESTIMATED TIME: 15 hours.

MATERIALS NEEDED FOR THIS COURSE

Study booklet, *Solar Energy as a Resource*

Exam: 2421, 9178 (answers)

Other materials:
Nearly all of the materials needed for this course are commonplace and can readily be found, if not already available. They are listed in DS #369 Activities for Solar Energy as a Resource where they are needed. A separate list of materials is provided in DS #9441 Solar Energy as a Resource Materials List for convenience.

NOTE TO STUDENT AND ACADEMIC/LAB SUPERVISORS

During this course, all data and calculations should be recorded in a notebook or computer file (or both if that is more convenient). It is standard practice in science for a researcher to keep a detailed and dated sequential record of what is done and the exact results obtained, for later reference by himself and others. This viewpoint should be kept in mind and practiced throughout the course when compiling these records. The course record will be shown to the supervisor for review after steps at the end of the course.

A. ENERGY, RADIATION AND HEAT

1. READ: Data Sheet (DS) #10 Energy. __________

2. DEMONSTRATION: Show the three things you should know about energy listed at the end of DS #10. __________

3. READ: DS #11 Matter and Energy in Natural Systems. __________

4. DEMONSTRATION: Show motion of matter and energy in natural systems. Show what stays in the system and what passes through it. __________

5. READ: DS #363 Radiation. __________

6. DEMONSTRATION: Show the three summary points given at the end of DS #363 (include the three things which may happen when radiation strikes matter). __________

7. DEMONSTRATION: Show the frequency of radio waves as compared to the frequency of visible light waves. __________

8. PRACTICAL APPLICATION: DS #369 Activities for Solar Energy as a Resource, Activity #1 Radiation (in the back of your study booklet). __________

9. PRACTICAL APPLICATION: DS #369, Activity #2 Reflection and absorption. __________

10. READ: DS #315 Climate and Weather Factors. __________

11. READ: DS #364 Heat and Temperature. __________

12. DEMONSTRATION: Show

    a) heat ___
    b) temperature ___
    c) heat capacity ___
    d) one calorie ___ __________

13. DRILL: Compute the amount of energy input in these situations (in calories or BTUs): (Answers are at the end of this study guide.)

    a) 1cc (cubic centimeter) of water is raised 10° C. ___
    b) 4cc's of water is raised 20° C. ___
    c) 2 lbs. of water is raised 18° F. ___ __________

14. PRACTICAL APPLICATION: DS #369, Activity #3 Molecular motion. __________

15. PRACTICAL APPLICATION: DS #369, Activity #4 Heat capacity. __________

B. SOLAR ENERGY

1. READ: DS #223 Seasonal Variations. __________

2. DEMONSTRATION: Show both reasons the amount of solar energy striking a certain area on the earth during a day varies with different times of the year. __________

3. READ: DS #826 Insolation. __________

4. DEMONSTRATION: Show the major factors that affect how much solar energy can be collected by a surface and why. __________

5. PRACTICAL APPLICATION: If the average over the whole planet of insolation arriving at the surface of earth during an entire day is about

250 watts per square meter, and the efficiency of solar cells is about 10%, calculate the surface area needed to provide all the world's energy needs using solar panels, assuming the panels receive this average insolation. Do your own internet research to find a reasonable estimate of the world's energy needs. Record your results and note where you found the data. An example answer is given at the end of this study guide. __________

6. READ: DS #365 Solar Energy Collection to heading "Natural Energy Collection." __________
7. DEMONSTRATION: Show why only about half of the solar energy arriving at earth reaches the ground directly. __________
8. READ: DS #365, section "Natural Energy Collection." __________
9. DEMONSTRATION: Show where hydrocarbon resources come from. __________
10. READ: DS #365, section "Our Fair Share?" __________
11. DEMONSTRATION: Show carbon sequestration, and the questions raised by human use of fire. __________
12. READ: DS #365, section "Artificial Energy Collection." __________
13. DEMONSTRATION: Show why the optimum orientation of a collector surface is directly facing the sun, and how you might choose an orientation for a surface that does not follow the sun. __________
14. READ: DS #365, section "Methods of Collection." __________
15. DEMONSTRATION: Show three major factors affecting the collection of solar energy, as mentioned at the end of the data sheet, and why they all have to be considered when developing a method of solar energy collection. __________
16. READ: DS #366 The Greenhouse Effect. __________
17. DEMONSTRATION: Show the greenhouse effect. __________
18. PRACTICAL APPLICATION: DS #369, Activity #5 Selective surface. __________

C. SOLAR PANELS

1. READ: DS #9175 Non-Electric Solar Panels. __________
2. DEMONSTRATION: Show how typical water panels collect, store and use solar energy. __________

3. READ: DS #9176 Solar Electric Cells. __________

4. DEMONSTRATION: Solar cells collect solar energy and convert it to electricity. Show how cells are combined to produce more voltage and more current (i.e., more power). __________

5. DEMONSTRATION: Show why practical solar-powered flight might be difficult to achieve. __________

6. PRACTICAL APPLICATION: DS #369, Activity #6 Solar panel. __________

7. PRACTICAL APPLICATION: On the internet, find a site that tells about solar panels. Find out about at least one way people use solar panels. __________

D. SOLAR STILLS

1. READ: DS #367 Distillation. __________

2. DEMONSTRATION: Show the three steps of the distillation process. __________

3. PRACTICAL APPLICATION: DS #369, Activity #7 Distillation. __________

4. ESSAY: Research and discuss five uses of distillation. ____ ____

5. READ: DS #368 Solar Stills. __________

6. PRACTICAL APPLICATION: On the internet, find a site that tells about solar stills. Find out about at least one way people use solar stills. Look for a simple solar still design you think you could build yourself for your final practical application. __________

E. FINAL APPLICATION SECTION

1. READ: DS #9177 The Solar Citizen. __________

2. ESSAY: Consider the points raised in DS #9177 The Solar Citizen, in light of what you have learned on this course about the prospects for using solar energy as a resource. Do additional research on the idea of zero-net houses or office buildings. Report your conclusions about the practicality of such efforts, now or in the future. Should the zero-net idea be considered a short-term or a long-term solution, as compared to the idea of total local self-sufficiency? Support your conclusions with actual data about cost per KWH of energy produced various ways, and energy storage needs. State your own opinion about your responsibility as a "solar citizen" to understand such efforts and the motives behind them. **Supervisor pass (see the course record).** ____ ____

3. PRACTICAL APPLICATION: With the materials available and your knowledge of solar energy and selective surfaces, decide on a design for a simple solar still. Your supervisor may provide help in choosing materials and advise on construction details, but the design choice should be yours. Build your still and test it on a sunny day by distilling salt water and observing the amount of fresh water produced.

   Do not expect to get a large amount of water on this trial. The idea is to get familiar with the concept and perhaps learn a technique that could apply in life if needed.

   If your first trial is successful, you may want to test your still more scientifically. First make any improvements you think are needed to make the still more efficient. Then start with a known amount of salt water in the still. Measure the amount of fresh water produced by exposure to the sun for an hour (or whatever amount of time is needed). Continue until a noticeable amount of distilled water is produced. If possible, measure the amount produced and compare that to the original amount of salt water.

   When you and your supervisor are satisfied with your still's operation, write a description of what you've done, the scientific principles utilized, and the results obtained. Summarize your conclusions about the potential benefits of this or similar devices.

   (Note: If you do not have a sufficiently sunny day, discuss with your supervisor about whether to try using a lamp to simulate sunlight. See the notes on the next page for help with this if needed.)

   Supervisor pass (see the course record). ____ ____

I have completed the steps of this course. I understand what I studied and can use it.

Student ______________________________ Date ______________________

The student has completed the steps of this course and knows and can apply what was studied.

Academic Supervisor ______________________ Date ______________________

The student has passed the exam for this course.

Examiner ____________________________ Date ______________________

Answers

A.13. a) 1cc (cubic centimeter) of water is raised 10° C. **10 calories**

b) 4cc's of water is raised 20° C. **80 calories**

c) 2 lbs. of water is raised 18° F. **36 BTU**

B.5. Find global power usage in watts. **≈ 2×10^{12} watts**
Divide by 25 to get number of square meters needed. **≈ 8×10^{10} square meters or 80 thousand square kilometers**

(If these figures are right, then a section of the Nevada desert less than 300 kilometers square should be able to power the whole planet. With a similar plot in the Sahara and another in the Gobi, the power could be continuous.)

E.3. Some hints for your Final Practical solar still design:

1. Refer to the course data about the greenhouse effect, as needed, to be sure you know why and how your chosen still design should work.
2. There are two reasons for having a dark surface on the bottom of the still: first to absorb sunlight and change it to heat, and then to transfer the heat to the water. The rate at which heat transfers to the water will depend on the area of the dark, wet surface. This will be greater if the surface is rough or porous.
3. Water can hold a lot of heat, so don't put too much water in your still to start with or it will take longer to start evaporating.
4. The still should be well sealed so that the moist, heated air inside cannot easily escape as it rises.
5. You can try using a fan to blow escaping heat away from the exterior of the still and keep the outer surface as cool as possible to improve condensation.
6. If you do not have a sufficiently sunny day, you can try using a lamp to simulate sunlight. From the course data, 250 watts per square meter is "average" sunlight and intense direct sunlight on a clear day can deliver 1,000 watts per square meter. The light from a 150-watt lamp directed at a still by a reflector should easily provide an equivalent amount of light on a smaller area. Avoid holding the lamp too close, as it is light energy, not heat, that you want impinging on your selective surface.
7. You can explore internet sites such as those listed below for more ideas:

    https://www.youtube.com/watch?v=a-cFKElV3RA

    http://www.desertusa.com/desert-people/water-solar-still.html