

**Instructions:** This test has the same format as before. Part A consists of short answer questions where you are to pick the best word, phrase, or choice of answers which best answers or, in some cases, defines the statement. Part B consists of longer answer questions. Make your answer clear and concise. If you need more room turn over the test paper and continue on the back but please indicate "over" on front. For problems it is the procedure that will be checked, not only the answer, so please try to make it clear. Please use the rules for precision or significant figures if *data* has been measured (indicated by the underline of the precision digit.) So for this, the second energy test of the term, Good Luck!

**DECLARATION:** I ELECT TO DO A (TP, LP, SOP). Please Circle.  
 If you have an idea of the title, please suggest it here: \_\_\_\_\_

A. Short Answer Questions

1.(10) REVIEW QUESTION PLUS: Choose from the physical quantities which we have discussed - length, area, volume, time, force, speed, acceleration, work, energy, power - to identify the following quantities taken from problems. (Note: In some blanks two quantities should be supplied.)

- |  |   |  |
|--|---|--|
| <u>work or energy</u><br>a) 573 KWH              | <u>power</u><br>f) 4,490 ft lb/s        | <u>power</u><br>k) 39.7 joules/s         |
| <u>speed</u><br>b) 47.3 miles/sec                | <u>force</u><br>g) 7.91 lb              | <u>work or energy</u><br>l) 10 calories  |
| <u>work or energy</u><br>c) 39.2 joules          | <del>power</del><br>h) 29.3 BTU/s       | <u>mass</u><br>m) 37.5 slug              |
| <u>work or energy</u><br>d) 29,700 ft lb         | <u>volume</u><br>i) 5.73 m <sup>3</sup> | <u>volume</u><br>n) 9840 ft <sup>3</sup> |
| <u>acceleration</u><br>e) 84.9 ft/s <sup>2</sup> | <u>speed</u><br>j) 27 ft/sec            | <u>power</u><br>o) 80 KWH/s              |

electrostatic precipitator  
 2. (1) A device for removing particles from the stacks of coal-fired power plants is called ?.

10  
 3. (1) About ? per cent of the heat from burning the coal in a coal-fired power plant goes up the stack.

carbon dioxide CO<sub>2</sub>  
 4. (2) The colorless, odorless gas given off in the burning of coal is called ? and is believed warming responsible for possibly producing ? of the earth.

EAST  
 5. (1) As a general rule, coal higher in BTU content but also higher in sulfur is found where?

6. (2) Oil is mainly formed by? decayed marine life under pressure in sandy soil

(a) Appalachian  
 7. (1) In what region of the country is most of the U.S. *anthracite* found? (a) Appalachian Mountains; (b) Eastern Interior Basin; (c) Northern Rocky Mountains; (d) Southern Rocky Mountains; (e) Alaska or (f) Hawaii.

sulfur  
 8. (1) A substance that is given off by the burning of coal by a power plant and that is believed to produce acid rain is called ?.

aquifers are disrupted  
 9. (2) List 2 problems that still exist even after coal companies have reclaimed the land.

differential settling  
 10. (2) The whistling tea pot effect refers to The large increase in pressure of steam when water is boiled, that can be used to turn a turbine.

32%  
 11. (2) Suppose 10.0 million BTU's are added to water to produce steam in a coal-fired power plant and 3.2 million BTU's of work are done. The first law efficiency of the power plant is 6.8 million is ? % and ? BTU's must be rejected to the coal reservoir.

$$E_f = \frac{W}{Q_H} \times 100\% = \frac{3.2 \text{ million}}{10 \text{ million}} = 32\%$$

$$\frac{10.0 \text{ } Q_H}{-3.2 \text{ } W}{6.8 = Q_C}$$

joules  
12. (1) REVIEW QUESTION: The combination of units of Nm is given another name—namely  
1 Nm = 1 J

12.0 m<sup>2</sup>  
13. (2) REVIEW QUESTION: A wall measures 3.0 m by 4.0 m. The area of the wall is ? m<sup>2</sup> or  
it also is ? cm<sup>2</sup>.  
120,000 cm<sup>2</sup>      300 × 400 = 120,000

11:54 14. (2) REVIEW QUESTION: If the doubling time of bacteria in a bottle were 2 min and the bottle was completely full at 12 noon, at what time would the bottle be 1/8 th full?  
11:56 1/4      11:58 1/2      11:54 1/4  
12 noon

4 yrs 15. (2) REVIEW QUESTION: The doubling time in years of a \$1 loaf of bread if inflation is increasing at a mere 5% per year is ? years. As time continues, the loaf of bread will continue to be more expensive. In ? years from now, the price of the loaf of bread will be \$8.  
42 years  
 $DT = \frac{70}{P} = \frac{70}{5} = 14 \text{ yrs.}$

16. (5) For the following measurements, indicate the precision and the number of significant figures. Carry out operations using strictly the rules for precision and significant figures. Include units!

	Precision	No. of significant figures
(a) 78.9 cm	<u>to the nearest tenth cm or ± 0.1 cm</u>	<u>3</u>
(b) 9.34 cm	<u>to " " hundredth " ± 0.01 cm</u>	<u>3</u>
(c) Measurements 78.9 cm x 9.34 cm =	<u>737 cm<sup>2</sup></u>	
(d) Measurements 78.9 cm - 9.34 cm =	<u>69.6 cm</u>	
(e) Measurements 78.9 cm + 9.34 cm =	<u>88.2 cm</u>	

17. (2) In the strip mining of coal, reclamation laws of most states require the coal companies to ?.  
return the land to the original level of productivity

18. (2) How is it determined that the land in question 17 has indeed been reclaimed?  
by an independent agency such as a university

19. (2) Coal deposits in some areas of the country are so low in BTU content that it does not make economic sense to ship the coal by rail. What then can be done? (Be as specific as you can.)  
Build a "mouth-fed" coal plant, burn the coal on site, + ship electricity (if > 500 mi via HV Power lines)

20. (2) Coal deposits in some areas of the country are sufficiently high that it does make economic sense to ship the coal by rail. What are these trains called? Describe them as specifically as you can.  
Unit trains. 2 Trains/day, 100 cars/train, ~ 100,000 lb of coal/car

320 joules  
21. (2) A 40 kg woman running at 4.0 m/sec has a kinetic energy of ?.  
 $KE = \frac{1}{2} m v^2 = \frac{1}{2} (40 \text{ kg}) (4.0 \frac{\text{m}}{\text{s}}) (4.0 \frac{\text{m}}{\text{s}}) = 320 \text{ kg} \frac{\text{m}^2}{\text{s}^2} = 320 \text{ joules}$

plastics  
fertilizer, clothing, medicine  
22. (2) List two uses for grades 3, 4, and 5 of oil.

heating of homes  
23. (2) One use grade 2 of oil is for ? while one of many uses of grade 6 of oil is for ?.  
asphalt + tar for roads. (This use to be used for Hamline heating 4 years ago.)

B. Longer Answer Questions

1. (3) REVIEW QUESTION: Albert Bartlett discusses the "forgotten fundamentals" in his classic article *Forgotten Fundamentals of the Energy Crisis*. Briefly discuss Bartlett's example of the mathematician, the king and the grains of wheat on the chessboard, and list two "fundamental" points that Bartlett was attempting to make.

The king was asked to repay the mathematician in grain by placing 1 grain of wheat on square 1, double to 2 grains on sq. #2, double to 4 grains on #3, 8 grains on #4, etc.

Fundamental points: (1) The doubling turns into enormous numbers very quickly (greater than the world-wide harvest of wheat in 1 year)

(2) The number of grains of wheat required for the next doubling time very nearly equals the sum of grains on ALL previous squares!

2. Suppose a 150 lb person climbs 120 steps, each step being 6.5 in high, in 40.0 sec.

- (a)(1) Where does the energy come from that allows the person to climb the steps?

From the food she eats + ultimately from the sun!

- (b)(2) What is the increase in the Gravitational Potential Energy (GPE) of person?

Increase in GPE = weight x height      weight = 150 lb

height =  $\left(\frac{6.5 \text{ in}}{\text{step}}\right) \left(\frac{1 \text{ ft}}{12 \text{ in}}\right) (120 \text{ steps}) = 6.5 \text{ ft.}$

Increase in GPE =  $(150 \text{ lb})(6.5 \text{ ft}) = 9800 \text{ ft}\cdot\text{lb}$

- (c) (1/2) Calculate the work done by the person in climbing the steps.

Work = increase in GPE = 9800 ft·lb

- (d) (1 1/2) Calculate the power done by the person in climbing the steps (in hp). NOTE: 1.0000 hp = 550 ft lb/sec.

Power =  $\frac{\text{work}}{\text{time}} = \frac{9800 \text{ ft}\cdot\text{lb}}{40.0 \text{ s}} = \left(\frac{250 \text{ ft}\cdot\text{lb}}{\text{s}}\right) \left(\frac{1 \text{ HP}}{550 \text{ ft}\cdot\text{lb}/\text{s}}\right) = 45 \text{ HP}$

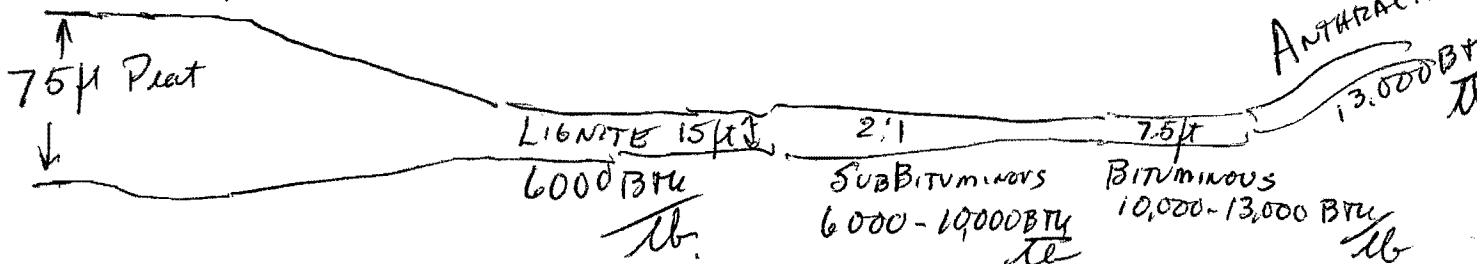
3. (4) A 6,000 watt air conditioner is run continuously for 17.5 hours. If electricity costs 11.3 cent per KWH find the cost of operating the air conditioner.

$P = 6.0 \text{ kW}$        $t = 17.5 \text{ H}$

ENERGY =  $Pt = (6.0 \text{ kW})(17.5 \text{ H}) = 105 \text{ KWH}$

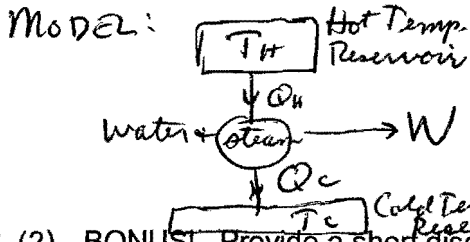
Cost =  $\left(\frac{11.3 \text{ ¢}}{\text{KWH}}\right) (105 \text{ KWH}) = 1190 \text{ ¢} = \$11.90$

4. (5) Start with a diagram of 75 ft of peat under extreme pressure from above and below. List the various names, thicknesses and BTU content of the grades of coal which can be formed from this initial thickness of peat.



5. (4) State the First Law of Thermodynamics. Use a typical model for a coal-burning power plant for your explanation. Also state the First Law Efficiency.

For any closed system, Energy is neither created nor destroyed; The total sum of all forms of energy add up to a constant.



$$\text{Energy In} = \text{Sum of Energy Out}$$

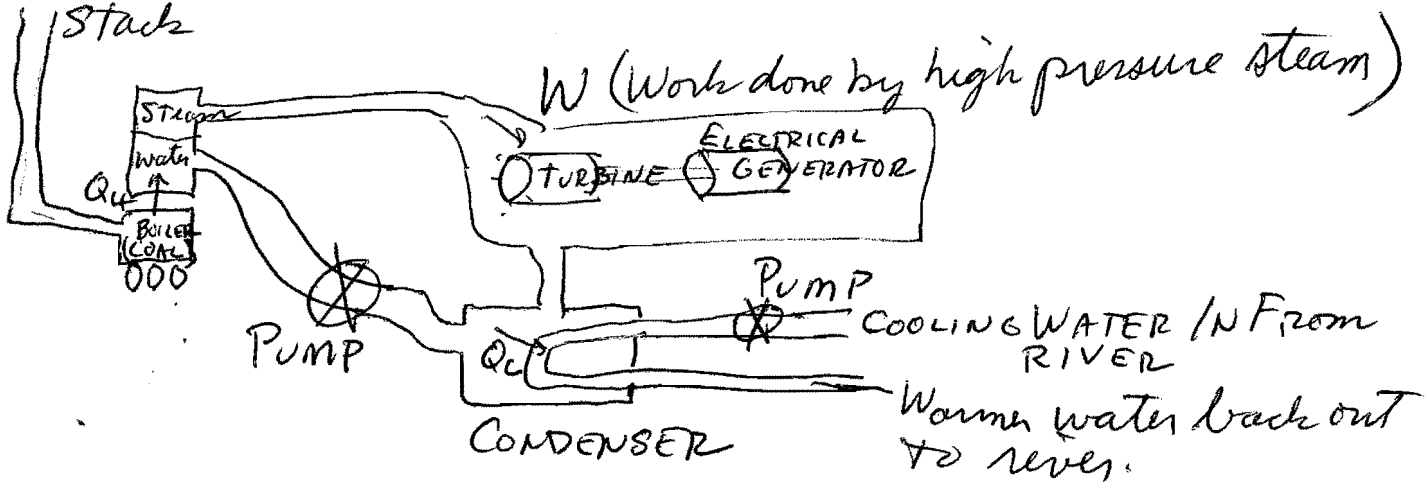
$$Q_H = W + Q_C$$

$$\text{1st LAW Eff} = \frac{W}{Q_H} \times 100\%$$

6. (2) BONUS! Provide a short discussion of the necessity of governmental regulation with regard to the environment in a capitalistic society.

- ① Without government regulation, there is no economic incentive for industry to restore land or preserve our ~~land~~ air and water.
- ② Regulation must be applied the same to all companies so that no single company has an economic advantage.

7. Draw a diagram of a typical coal-fired electrical power plant. Indicate as best you can the boiler where the coal is burned, the turbine, condenser, the stack (4). Note where heat is added  $Q_H$ , where work  $W$  is done, and where heat  $Q_C$  is removed (1). Indicate in your diagram where pumps would need to be located. (1).



8. (4) Briefly discuss three of the four equivalent statements of the Second Law of Thermodynamics as discussed in class. Also, state the Second Law Efficiency.

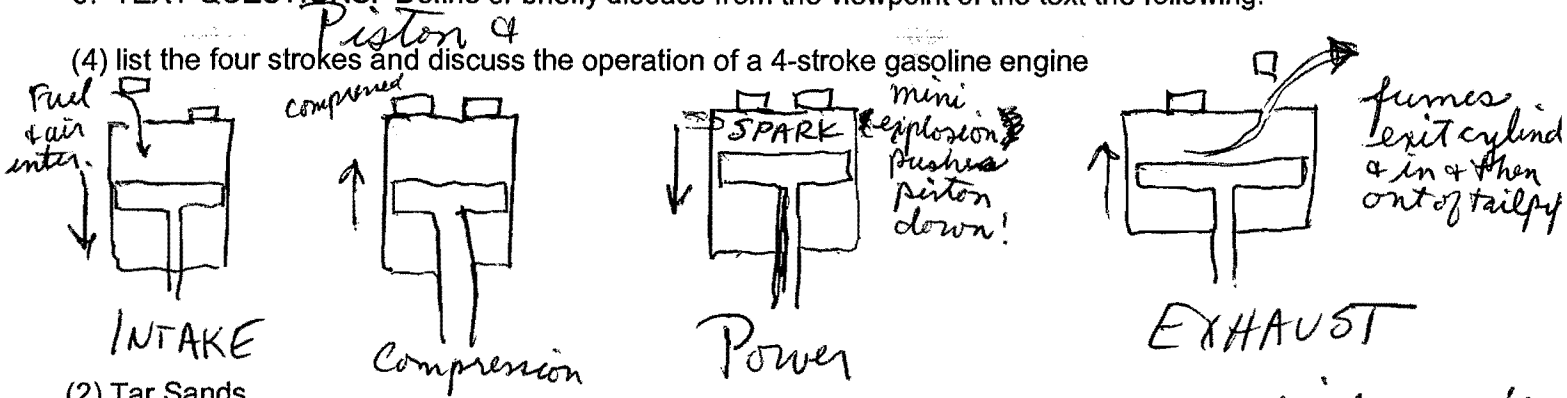
① There is a directionality in nature: Heat flows from HOT to Cold.

②  $Q_H = W$  is impossible. 100% Eff Heat Engines (+ perpetual motion machines) will never be achieved

③ Disorder of any closed system increases, or at best remains the same.  $2\text{ND LAW EFF} = \frac{\text{minimum Energy to accomplish}}{\text{Energy content of fuel used}} \times 100\%$

④ Depreciation in any economic process exists & must be accounted for.

9. TEXT QUESTIONS: Define or briefly discuss from the viewpoint of the text the following.



(2) Tar Sands

Tar Sands are sand deposits that contain a very thick crude oil substance (called bitumen) that can be processed into grades of oil. Tar Sands are mainly found in Alberta, Canada & are being actively extracted.

(2) Kerogen

Kerogen is a solid substance that can be extracted from oil shale, heated, and processed into grades of oil. The big U.S. oil shale deposit is the Green River Formation in Utah, Colorado, & Wyoming.

(2) Tertiary recovery is an enhanced recovery of oil process that uses steam <sup>or CO<sub>2</sub></sup> injection to reduce viscosity of oil and/or uses ~~surfactant~~ <sup>detergents</sup> injected to reduce surface tension.

(2) PURPA "Public Utilities Regulatory Policies Act" was passed in 1978 to require public utilities to purchase excess electricity from "cogenerators." Cogenerators are exempt from regulation & utilities are req'd to connect to them.

(2) Coefficient of Performance essentially is the "efficiency" of a heat pump when electrical work is done (what you have to pay for) in order to supply heat  $Q_H$  to a home. Here  $EOP = \frac{Q_H}{W}$

(2) Radioactivity is the term given to the decay products given off ( $\alpha$ ,  $\beta$ , or  $\gamma$ ) by an excited "radioactive" nucleus. These decay particles do damage!

(2) Alpha Particle is one of the decay products of a radioactive nucleus that consists of 2 protons & 2 neutrons (a He nucleus), carries a positive charge, & can be stopped by a piece of paper.