

Instructions: This test has the same format as before. For problems in the longer answer section, show your work; your work will be checked as well as your answer. For short answer questions, pick the best answer for the multiple-choice questions.

DECLARATION: _____ is the topic of my (term paper, short oral presentation, lab project) (choose one). This topic (has, has not) been approved. (Please circle.)

.199 HP
1. (2)
(USING "1" RULE)

REVIEW QUESTION: If a 952 ft lb of work are done by a motor in 8.7 sec, the power of the motor in hp is ?. Note: 1 hp = 550 ft lb/s. $P = \frac{W}{t} = \frac{952 \text{ ft-lb}}{8.7 \text{ s}} = \left(\frac{109 \text{ ft-lb}}{\text{s}} \right) \left(\frac{1 \text{ HP}}{550 \text{ ft-lb/s}} \right) = .199 \text{ HP}$

2. (4) **REVIEW QUESTION:** For the following two length measurements indicate the precision and number of significant figures for each, add them, and multiply them using the rules strictly. (Include units.)

	<u>Precision</u>	<u>No. of significant figures</u>
a) 7.4 m	to the nearest tenth m or $\pm .1 \text{ m}$	<u>2</u>
b) 2.41 m	" " " hundredth m or $\pm .01 \text{ m}$	<u>3</u>
c) sum of 7.4 m + 2.41 m equals	<u>9.8 m</u>	
d) product of 7.4 m times 2.41 m equals	<u>17.8 m²</u> (using "1" rule)	

17% 3. (2)
5 million

REVIEW QUESTION: Suppose 6.0 million BTU's are added to water to produce steam in a coal-fired power plant and only 1.0 million BTU's of work are done. The first law efficiency of the power plant is ? % and ? BTU's must be rejected to the cold reservoir.

→ protons, nucleus
4. (1)
isotopes
5. (1)

In a neutral atom the number of electrons is equal to the number of ? in the ?.
Two nuclei having the same number of protons but a different number of neutrons are called ? of each other.

38 6. (4)
52

The number of protons in the nucleus ⁹⁰Sr is ? while the number of neutrons is ?. The number of electrons in each of the shells is ?, ?, ?, ?, and ?.

90
-38
52

625 7. (2)

If 10,000 ²⁴Na nuclei are found in a sample, how many remain after 32 minutes if the half life is 8 minutes?

Now 10,000 ²⁴Na 24 min 1250
8 min 5000
16 " 2500
32 min 625

Three gastrointestinal tracks 8. (2)
Three skin, breathe in through lungs.

List 2 ways that a radioactive substance may enter the body. of 3 ways.

9. (4) Of the three types of nuclear radiation,

alpha (a) the type that was later found to be a Helium nucleus.

gamma (b) the type that is not charged at all is ?

Beta (c) the type that was later found to be an electron is ?

gamma (d) the type that carries the most energy ?.

10. (2) When radioactive Calcium is injected into the intestinal tract, the rat's body transports a radioactive atom in the body the same as it does if that atom were stable. Why? The body looks at the arrangement of electrons & both radioactive Ca & stable Ca has the same arrangement; the body cannot tell the difference

light water reactor (3) breeder reactors fusion reactors Three stages, for the conversion of U.S. Energy to Nuclear Power, were initially devised in the "Atoms For Peace" program. Here, the 1st stage was ?, the 2nd stage was ?, and the 3rd stage was ?.

takes away heat slows down neutrons The purpose of the water in the light water reactor is two-fold: it ? and it ?.

false 13. (1) The bad part about a nuclear reactor is that it could explode such as an atomic bomb. (True, False)

→ Natural Uranium & ^{239}Pu 14. (2) The fuel required for a breeder reactor is ? and ?

→ Liquid Sodium 15. (2) The substance that takes away the heat in a breeder reactor is not liquid water but instead is ? because liquid sodium keep neutrons moving fast

SCRAM 16. (1) An emergency shut down procedure of a nuclear reactor is a process which is called ?.

LIGNITE 17. (3) REVIEW QUESTION: A type of coal that is found in the North Dakota that only has a BTU content of 6000 BTU/lb is called ?. This BTU content is so low that it does not make economic sense to ship the coal by train. Instead, what is done?

Use a mouth-fed power plant; burn coal on site & transport electricity (HV if > 500 mi away)

mrem 18. (2) Radiation damage to human tissue is measured in units of ?; for one year, the average radiation damage per person occurring from nature itself is approximately ?.

^{235}U ^{239}Pu 19. (2) Two of three known fissionable isotopes which would be available for nuclear power plants (or even nuclear bombs) are ? and ?.

20. (2) Define "neutron moderation." The slowing down of neutrons

(c) lin of styrofoam

21. (1) Which of the following has the larger R-value?
 (a) 1 in of softwood; (b) 2 in of hardwood; (c) 1 in of STYROFOAM;
 (d) single pane glass; (e) 1 in of stone; (f) double pane glass

2.0 22. (1) A storm window (namely two panes of glass) has an R-value of about ?.

$\frac{980 \text{ BTU}}{\text{H}}$ 23. (2) BONUS QUESTION!!!!: On a winter day when the inside temperature is 75°F and the outside temperature is 10°F, the energy lost through a 3.0 ft by 5.0 ft single pane window with total R-value of 1.00 is ? BTU per hour.

$$\left(\frac{Q}{t}\right)_{\text{COND}} = \frac{\text{Area} \times (T_H - T_C)}{R_T} = \frac{(15.0 \text{ ft}^2)(65^\circ\text{F})}{1.00} = \frac{980 \text{ BTU}}{\text{H}}$$

B. Longer Answer Questions

1. (3) (a) What is meant by the "envelope" of a house?

The outer walls, ceiling, and bottom (basement) floor that wraps entirely around the warm, ~~to~~ heated living area of a home that separates the warm inside from the (cold, if winter) outside.

2. (4) List and discuss three advantages of nuclear power in the United States. Contrast that with three disadvantages.

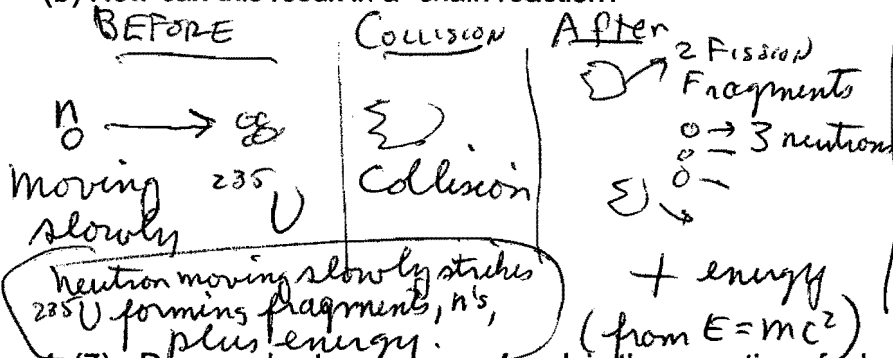
ADVANTAGES

- ① Cheaper ^{fuel} than coal for existing plants
- ② No CO₂ emitted
- ③ We need (& will need) electricity!
- ④ Lessens dependence upon coal ^{etc}

DISADVANTAGES

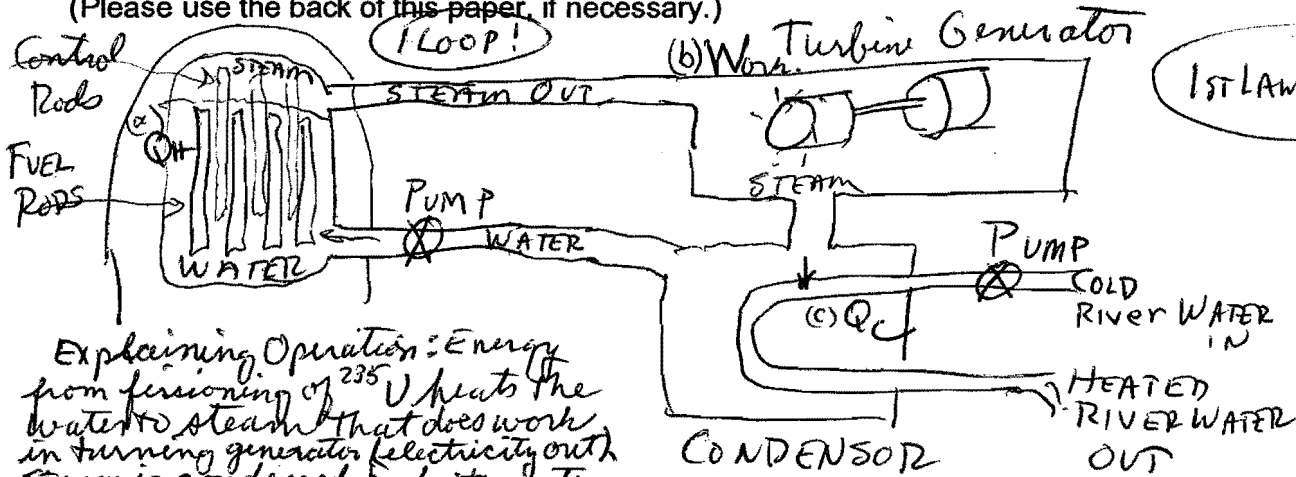
- ① Much transportation of nuclear materials req'd.
- ② Nuclear Waste is building up.
- ③ Sabotage risks.
- ④ Lifetime is finite — perhaps 60 years

3. (4) (a) Draw a diagram and explain what happens for a single fission event using a neutron and ²³⁵U. (b) How can this result in a "chain reaction?"



Neutrons from fission can be slowed by water & in turn strike other ^{235}U nuclei. etc! (A lot of energy!)

4. (7) Draw, as best you can, and explain the operation of a boiling water reactor. Be sure to include in your diagram the fuel rods, control rods, turbine and generator, and all pumps. Also point out (a) where heat is added, (b) where work is done, (c) where heat is removed from the water, and (d) write down an expression for the First Law of Thermodynamics and for finding the "first-law efficiency" for the boiling water reactor (Please use the back of this paper, if necessary.)



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

Explaining Operation: Energy from fissioning of ^{235}U heats the water to steam that does work in turning generator electrically out. Steam is condensed back to water & pumped back into reactor.

The neutrons can be absorbed by pushing in control rods if you wish to reduce heat, steam, and electrical output (and vice versa).

5. (4) (a) (2) Explain what happened at Chernobyl. (b) (1) What kind of a reactor was this? (c) (1) List a method that people could protect themselves from the radioactive iodine that was included in the radioactive cloud that continued to move over Scandinavia and E. Europe.

(a) The plant was turned over to Electrical Engineers to do tests. They turned off safety controls & inadvertently when thru unstable region that led to a huge explosion, fire, + release of radioactivity to surrounding countries. (b) GRAPHITE Reactor (c) People could saturate their bodies with stable iodine so that the radioactive iodine would pass straight on through!

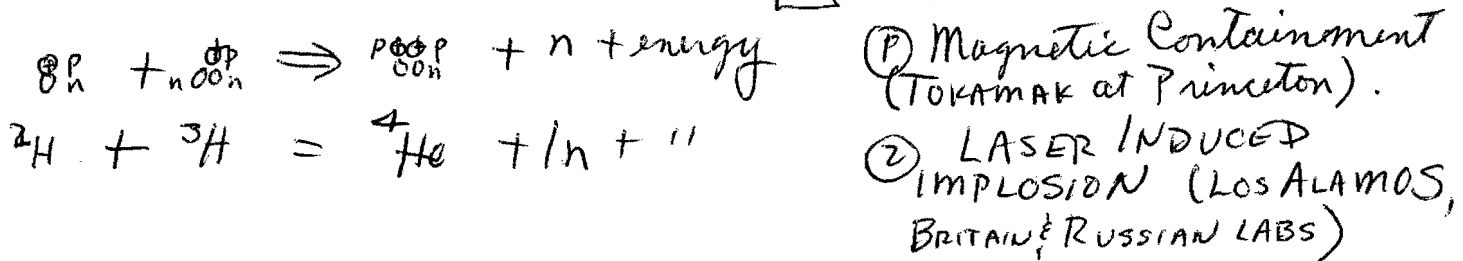
6. (3) How does a breeder reactor differ from the light water reactors? ^(b) What heat transfer agent does it utilize? What country has gone "all out" with regard to the breeder reactor?

- (a) A breeder reactor used plutonium ^{239}Pu & natural uranium ($99\% \text{ } ^{238}\text{U}$) as the fuel. It also uses liquid sodium as the heat transfer agent. The original U.S. breeder design had 3 loops compared to 1 + 2 loops for the light water reactor.
- (b) Liquid sodium
- (c) France

7. (4) REVIEW QUESTION: 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) Heat flows from HOT to COLD ~~temperature~~ (over time heat death of universe???)
- (2) $\frac{Q_H}{Q_C}$ is impossible. 100% efficient heat engines not possible. Perpetual motion machines not possible.
- (3) Disorder (entropy) increases for a closed system or at best remains the same.
- (4) Depreciation exists for any economic process & must be accounted for.
- 2ND LAW EFF = $\frac{\text{minimum energy necessary to accomplish task}}{\text{energy content of fuel used to accomplish task}} \times 100\%$

8. (3) How is energy obtained from nuclear fusion, and what two techniques are presently being researched?



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

- (2) China Syndrome ^{is the term given to} ~~describes~~ a total meltdown by a nuclear reactor whereby it melts thru the ground & contaminates the water supply. (It does not melt thru the earth all the way to China! :) (This was also made into a movie!))
- (2) Manhattan Project is a crash program developed by the U.S. during WW II to produce an atomic bomb before the Germans. Both a ^{239}Pu bomb and a ^{235}U bomb were developed.
- (2) Critical Mass is the minimum mass that will sustain a chain reaction ($\sim 20\text{kg}$ of ^{235}U and $\sim 10\text{kg}$ of ^{239}Pu).

- (2) R-value - is the resistance to heat flow by conduction
- (2) Radon - is a radioactive daughter of ^{238}U decay that is a gas that seeps into the basement of our homes & builds up over time & can cause lung cancer.
- (2) Carbon monoxide CO is a toxic molecule breathed in by the human body & results in nausea, fainting & death! CO is produced by insufficient oxidation in the combustion process.
- (2) Active system of solar power consists of a flat-plate collector & a pump to drive the ~~of~~ fluid through the flat-plate collector & eventually into storage of heat.
- (2) photovoltaic cells - or PV cells consists of Silicon (& other elements) and converts solar electromagnetic radiation to DC electricity.
- (2) power tower - consists of mirrors that track the sun & concentrate its rays on to a boiler. The boiler becomes very hot, turns water into steam that turns turbine to produce electricity.
- (2) pumped storage - Utilities at night during low power usage will pump water into the high water level of an artificial dam so that hydroelectric power can be used during the day during high power usage.
- (2) OTEC - Ocean Thermal Energy Conversion utilizes the difference in ocean temperature to produce electricity. It does this by boiling ammonia (at surface ocean temperatures) to turn a turbine/generator & then condensing ammonia back to liquid at colder, deep ocean levels. A pump drives _{system}