Final Exam Review Activity  Physics 100  May 9, 2018  Name:________________________
Professor Menningen

Section I. Answer True (+) or False (O)
1. Molecules at 200 ºC have twice the average kinetic energy than molecules at 100 ºC.
2. A heat engine can do mechanical work using the thermal energy in ice water if the exhaust temperature is at the boiling point of liquid nitrogen.
3. The mechanical energy of a pendulum is greatest at the midpoint and smallest at the endpoints of the motion.
4. Heat can flow spontaneously (by itself) only from a hot source to a cold sink.
5. Iron-56 has the largest binding energy per nucleon of any known isotope.
6. A step-down transformer is used to decrease the current flowing from an electric power plant.
7. The electric potential of charges is commonly measured in watts.
8. One important requirement of a solar energy heating system is that it is able to store energy for nighttime use and for cloudy days.
10. A global increase in temperature might produce an enhancement of ocean circulation that would increase the rate at which warm water is delivered to some areas such as Europe.

Section II. Answer the following questions by circling the appropriate letter.
11. Given that ice has a specific heat that is one-half that of water, does it take more thermal energy to raise the temperature of 5 grams of water or 5 grams of ice by 6 ºC?
   a. ice
   b. water
   c. It takes the same thermal energy for each one.

12. If a 60-kg sprinter can accelerate from a standing start to a speed of 10 m/s in 2.0 seconds, what average power is generated?
   a. 600 W
   b. 1500 W
   c. 3000 W
   d. 6000 W

13. Suppose two cars have the same mass, but the green car has one-third the speed of the black car. We then know the green car has ____ kinetic energy of the black car.
   a. nine times
   b. three times
   c. one-third
   d. one-ninth
14. If a system has no change in thermal energy, we can say that
   a. the work done on the system was equal to the heat released.
   b. no work was done on the system.
   c. the system lost no heat.
   d. any flow of heat energy produced no temperature change.

15. Which of the following is NOT a unit of energy?
   a. calorie
   b. newton · meter
   c. kilowatt · hour
   d. watt

16. The fissioning of $^{235}$U can produce a chain reaction because it
   a. releases two or three neutrons.
   b. is unstable to radioactive decay.
   c. converts mass into energy.
   d. emits photons

17. Which of the following is NOT an example of biomass energy?
   a. Methane gas from municipal landfills.
   b. Hydrogen gas from electrolysis of water.
   c. Compressed sawdust for wood pellet stoves.
   d. Ethanol from fermentation of sugarcane.

18. A radioactive substance decays at the rate of 0.70% per minute. What is the half-life?
   [Hint: remember the video on exponential growth!]
   a. 1.4 min
   b. 70 min
   c. 100 min
   d. 693 min

19. What is a disadvantage of using an inexpensive extension cord (with a small-diameter wire) to
   operate a high power air conditioner?
   a. A large voltage drop across the wire will supply too much voltage to the air
   conditioner and damage the unit.
   b. The large current required by the air conditioner will heat the extension cord
   wire and cause a fire hazard.
   c. The thin wire will generate large magnetic fields that can be a health hazard.
   d. The thin wire draws extra current from the outlet and will increase the cost of
   operating the unit.

20. Geothermal energy is an attractive option because
   a. it is a source of energy with essentially zero environmental impact.
   b. it can be effectively harnessed to produce electricity nearly anywhere in the U.S.
   c. it provides high quality heat to run a highly efficient heat engine.
   d. it can provide around-the-clock electricity with almost no gas emissions.
21. One example of a negative “feedback” to global climatic warming is that
   a. the additional water vapor will produce more clouds that efficiently absorb sunlight.
   b. the extra plant growth will result in additional carbon absorption.
   c. the melting of the polar icecaps will cause the Earth to reflect more light into space.
   d. the warming of the oceans will cause them to release more CO₂.

22. Which of the following is NOT a viable solution to the "acid rain" problem?
   a. Install flue-gas chemical desulfurization units for scrubbing exhaust gases.
   b. Arrange for power plants to burn fuel with a lower sulfur content.
   c. Use an electrostatic precipitator to remove the SO₂ before it is released in
      the exhaust of power plants.
   d. Use fluidized bed combustion in power plants to remove SO₂ as soon as it is formed.

23. Which of the following is NOT a common crude oil refinery product?
   a. ethanol
   b. paraffins
   c. jet fuel
   d. asphalt

24. Which of the following would make the best thermal energy storage system?
   a. 500 m³ (600 kg) of air (cₐᵋᵐᵋᵐᵋ = 1000 J/kg·°C)
   b. 400 gallon (1,500 kg) of water (cₜₜₜₜ = 4186 J/kg·°C)
   c. 20 ton (20,000 kg) of concrete (cₜₜₜₜ = 960 J/kg·°C)
   d. 10 ton (10,000 kg) of rocks (cₜₜₜₜ = 840 J/kg·°C)

25. The United States can increase its coal reserves by
   a. decreasing the rate at which it consumes coal
   b. mining more coal from the known deposits
   c. building larger containers in which to store extra coal
   d. finding an inexpensive way to remove coal from very deep deposits.

Section III. Answer the following questions by writing a symbolic expression, showing work leading
to the answer, and boxing the answer with units.

A. A pendulum bob changes height by a total of 71.0 cm from one end of its swing to its lowest
   point. What is the speed of the pendulum bob at the lowest point?
B. When an ideal gas was compressed, its thermal energy increased by 220 J and it gave off 170 J of heat. How much work was done on the gas?

C. A typical coal-fired electric power plant has an efficiency of 36.0%, while a nuclear power plant is 31.0% efficient. How many joules of thermal energy are required by each plant to generate one joule of electrical energy? How much heat does each plant exhaust as waste?

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<tr>
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<th>Coal Plant</th>
<th>Nuclear Plant</th>
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<tbody>
<tr>
<td>Fuel $Q_H$ (J)</td>
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<td>Waste $Q_C$ (J)</td>
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D. The common exit sign in a public building uses two 15 W incandescent bulbs. These could be replaced with light emitting diodes (LEDs) at 1.9 W per sign. If there are 45 million signs in use in the United States, what savings in electricity use for an entire year (8,760 hours) could be secured with this changeover? Use $0.10/kWh as the cost of electricity.
E. Power is generated at 24 kV at a generating plant located 109 km from a town that requires 50 MW of power at 12 kV. The voltage will be stepped up from 24 kV to some voltage $V$ by a perfect transformer, transmitted over wires, and then stepped down to 12 kV by another perfect transformer. The two transmission lines in between the two transformers each have a resistance of 0.10 Ω/km. What should be the output voltage $V$ of the transformer at the generating plant in order for the overall transmission efficiency to be 98.5%? Find the answer by completing the following steps.

a) First determine how much power must be generated at the plant in order to deliver the required power at the town. (Enter your answer to the nearest 0.001 MW.)

b) The difference between these two powers is the amount of power that is converted to heat by the resistance of the transmission wires. How much power is lost to the heating of the transmission lines? (Do not round off your value from part a)

c) The next step is to find the total resistance of the two wires.

d) Determine the amount of current flowing through the wires that corresponds to the power lost to heating during transmission.

e) Finally, use the generated power at the plant, together with the amount of current flowing through the wires, to find the required output voltage $V$ of the transformer at the generating plant.
F. If the ratio of $^{14}\text{C}$ to $^{12}\text{C}$ in a piece of parchment is only 1/256 of the atmospheric ratio, how old is the parchment? The half-life of $^{14}\text{C}$ is 5715 years.

G. Ten tons of ocean water are processed to extract 1.56 kg of deuterium for use in a nuclear fusion reactor. Only 0.116% (that is, 0.00116 kg out of each kilogram) of deuterium fuel is converted into energy during the fusion process. If your fusion-powered electrical generating plant is 25% efficient, how many kWh can you generate from the ocean water?

H. Stevens Point has an average insolation of 15.5 MJ/m$^2$/d. If you buy a 8.0 m × 2.0 m solar array that is 18% efficient, how many kWh can it generate in a month (30 days)?