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Essay questions (40 pts): pick **two** and only two to answer. Write a page on the **back** of a separate sheet for each. For each sheet, circle the question that you chose. This side is for your personal notes only. Cover the important points in a clear and concise manner – as if you have only a few minutes to tell the President, your roommate, or your parent, what that person needs to know. *Clear, effective writing is important.* If English is not your first language, state so at the top of your essay. If you need to re-write it, ask for a new sheet.

1. Energy and Power. An electric power plant "creates" energy from fuel. Fossil fuels include oil, coal, and natural gas. List three *other* (non fossil fuel) sources of energy that are used or will be used in the near future. What are the advantages and disadvantages of each? For each, describe how the fuel is used to generate electricity. Once it is created in the power plant, what additional steps are used to bring electricity into your home? Try to be detailed, but concise.

2. Visible light is an electromagnetic wave. Name five other phenomena that are also electromagnetic waves but have different names. (Try to pick things that a non-physics student would not know was "light".) How do these waves differ? Briefly describe applications for each of these waves.

3. Quantum phenomena. Many people think "quantum physics" is used only in the laboratory. In fact, many devices that depend on quantum physics for their operation are used in business, industry, and our everyday lives. Give examples of four such uses, and for each one, describe how quantum physics is essential for its operation. Try to pick four devices that appear, to the non-physics student, to be as different from each other as possible.

Use a separate sheet for each essay.
This side is for name and notes only.
The essay should be on the next sheet.

Short questions (1 point each, 40 points total). Read the questions carefully so that you don't misinterpret them (e.g. by missing a word such as "not"). Circle the correct answer. Make sure you do all four pages of these short questions.

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1. Liquid hydrogen, compared to gasoline, has
 - a. 3 x more energy per gallon
 - b. 3 x less energy per gallon
 - c. about the same energy per gallon
 - d. 10 x more energy per gallon
 2. The "hydrogen economy" that is talked about in newspapers:
 - a. will pump hydrogen gas from oil wells
 - b. will use fusion to convert hydrogen to helium
 - c. will burn hydrogen instead of gasoline in a piston engine (internal combustion) engines.
 - d. will use hydrogen to store energy
 3. An hour of vigorous exercise will use up an amount of fat of approximately
 - a. one gram
 - b. one ounce (28 grams)
 - c. one pound(454 grams)
 - d. three pounds
 4. At high velocities, most of the fuel of an automobile is used
 - a. to overcome tire-road friction
 - b. to increase the kinetic energy of the auto
 - c. to keep the engine running (overcome internal friction)
 - d. to overcome air resistance
 5. At $T = 300\text{ K}$
 - a. hydrogen moves faster than oxygen
 - b. all molecules have the same velocity
 - c. oxygen moves faster than hydrogen
 - d. all molecular motion stops
 6. At which temperature does sound travel fastest in air?
 - a. 300 K
 - b. 100 C
 - c. 0 C
 - d. 0 F
 7. A can of coke feels colder than a plastic bottle of coke because
 - a. metal has a lower freezing point
 - b. the can gets colder in the refrigerator
 - c. plastic is lighter than metal
 - d. metal conducts heat better than plastic
 8. The mystery of "firewalking" can be explained by
 - a. low conduction of sweat
 - b. Moore's Law
 - c. Ewing's Rule
 - d. Leidenfrost Effect
 9. Which satellite is highest?
 - a. spy satellite
 - b. GPS
 - c. satellite TV
 - d. oil exploration satellite
 10. Rail guns are not practical for launching humans to space because
 - a. the g's are too high, for a reasonably short railgun
 - b. electricity is more expensive than rocket fuel
 - c. there is no need for ultra high velocities
 - d. they cannot achieve velocities greater than about 1 km/sec.

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11. If they all worked as planned, the **least** efficient way to get into space would be:
 - a. skyhook
 - b. rocket
 - c. shot from a gun
 - d. hypersonic airplane
12. Fallout is dangerous. Which of the following causes the greatest concern?
 - a. tritium
 - b. plutonium
 - c. uranium
 - d. strontium
13. In Hiroshima, cancer deaths from radioactivity accounted for (pick which is closest)
 - a. 1% of all deaths
 - b. 6 % of all deaths
 - c. 37% of all deaths
 - d. more than 80% of all deaths
14. After 3 half lives, the remaining radioactivity is what fraction of the original?
 - a. 0
 - b. 1/3
 - c. 1/6
 - d. 1/8
15. Muller wears a radioactive watch because
 - a. he is incredibly brave
 - b. gamma rays don't cause cancer
 - c. he is incredibly stupid
 - d. the radiation never reaches his skin
16. Which material would be most convenient for a terrorist who wanted to construct an atomic bomb?
 - a. U-235
 - b. depleted uranium
 - c. Pu-239
 - d. deuterium and tritium (or Li-6)
17. The source of power in the sun is
 - a. fission
 - b. fusion
 - c. radioactivity
 - d. annihilation
18. Fusion requires
 - a. a neutron chain reaction
 - b. highly radioactive nuclei
 - c. uranium or plutonium
 - d. high temperature and pressure
19. If radiation were NOT present in the environment, the percentage of US population that would die of cancer would be approximately:
 - a. 1%
 - b. 3%
 - c. 10%
 - d. 20%
20. To purify uranium, Saddam Hussein planned to use:
 - a. centrifuges
 - b. magnetism (calutron)
 - c. lasers
 - d. gas diffusion
21. "High temperature superconductors" operate at approximately:
 - a. room temperature
 - b. 4 K (liquid helium temperature)
 - c. -123 C (liquid nitrogen)
 - d. 2000 C
22. The Earth's magnetism comes from
 - a. a dynamo in the core
 - b. permanent magnets in the core
 - c. iron in the crust
 - d. monopoles near (but not at) the North and South geographic poles

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23. A Tesla coil is a kind of
a. transformer
b. dynamo
c. radio transmitter
d. sensor for the Curie point
24. A Richter 9 earthquake, compared to a Richter 8 earthquake
a. has twice the energy
b. has 10-30 times the energy
c. has velocity 2 x faster
d. has velocity 10-30 x faster
25. In music, an octave in frequency is a factor of
a. square-root of 2
b. 2
c. 4
d. 8
26. The Doppler shift for galaxies
a. is usually towards red
b. is usually towards blue
c. is blue and red about equally
d. has not yet been observed
27. The L wave is often the most damaging because
a. it stays on the surface, so doesn't spread out very much
b. it moves slowest, so it has the greatest energy per mile
c. the S and P waves carry too little total energy
d. It arrives first, before people have a chance to take cover
28. Older people are often "farsighted" because
a. Their cornea has become more curved
b. Their lens is less flexible, so it can't focus close
c. Their retina gains resolution with time from the growth of more cells
d. Their lens has become less curved
29. A stealth airplane
a. bounces no radar
b. bounces radar away from the radar receiver
c. detects radar and cancels it by generating an opposite wave
d. contains many corner reflectors
30. Let the speed of light in a vacuum be c . Then the speed of light in a piece of glass with index of refraction 1.5 is
a. less than c
b. c
c. greater than c
d. depends on the dispersion of the glass
31. Ice ages occur because of
a. end of greenhouse warming
b. destruction of the ozone layer
c. changes in the brightness of the Sun
d. changes in the orbit of the Earth
32. To image the hydrogen in the body, use
a. PET
b. MRI
c. CAT
d. x-rays
33. According to the text, an amplifier is similar to
a. a valve
b. an electric power station
c. a focusing lens
d. a battery
34. A moving object is
a. shorter and younger
b. longer and older
c. shorter and older
d. longer and younger

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35. According to Muller, tachyons
- have been produced by him
 - are made only by large accelerators
 - are theoretically impossible
 - conflict with "free will"
36. The age of the Universe is closest to:
- 100 million years (10^8)
 - 1 billion years (10^9)
 - 10 billion years (10^{10})
 - 1 trillion years (10^{12})
37. What was made in the first 4 minutes?
(mark all that are correct)
- hydrogen
 - helium
 - carbon
 - iron
38. The expansion of the Universe is accelerating. Physicists attribute this to:
- the Hubble expansion
 - dark matter
 - dark energy
 - antimatter
39. Light from Andromeda reaches us in
- several minutes
 - several years
 - several millions of years
 - several billions of years
40. Electrons cannot go as fast as light because
- of the uncertainty principle
 - it would violate free will
 - they would expand to infinite size
 - it would take infinite energy