1. Which of the following is not a “renewable” energy resource?
   A. solar
   B. wind
   C. hydroelectric
   D. nuclear
   E. biomass (wood, biofuels, cow-dung)

2. What percentage (0 to 100) of our total energy budget (in the U.S.) do you think comes from renewable resources (not mined/drilled)?

3. From 1994 to 2003, what do you think our use of renewable energy has done?
   A. gone up
   B. gone down
   C. stayed the same
   D. no opinion/guess

4. How do we interpret the “solar constant” of 1370 W/m^2?
   A. Any panel would receive 1370 J in one second
   B. A 1 m^2 panel would receive 1370 J
   C. A panel would receive 1370 J in a year
   D. A 1 m^2 panel would receive 1370 J in one second
   E. A 10 m^2 panel would receive 1370 J in 0.1 seconds

4. If 5/8 of the total light available at the top of the atmosphere reaches the ground on a cloudless day, how much light power density would you expect to see at the ground?
   A. about 200 W/m^2
   B. about 650 W/m^2
   C. about 850 W/m^2
   D. about 1370 W/m^2
   E. no basis for judgement

6. On a sunny day, if you get 850 W/m^2 of sunlight, how large would a flat, black panel in your house (in full sun) have to be to produce the equivalent of a 1700 W space heater?
   A. about 1 m^2
   B. about 2 m^2
   C. about 4 m^2
   D. about 10 m^2

7. What percentage of the U.S. land area do you think would need to be covered by solar panels to generate *all* of our energy needs?

8. If your household can get by with an average power of 400 W, how much solar panel do you need at 10% efficiency at an average insolation of 200 W/m^2?
   A. 2 m^2 = 22 ft^2
   B. 4 m^2 = 43 ft^2
   C. 10 m^2 = 108 ft^2
   D. 20 m^2 = 216 ft^2
   E. 40 m^2 = 430 ft^2

9. What is the flux of solar power at the earth, above the atmosphere, in W/m^2?

   hint: numerical answer less than 10,000

10. What is a typical sunlight flux in W/m^2 on the ground (below the earth's atmosphere) on a clear day?

    hint: answer will be less than previous

11. Power delivered by electricity is voltage times current (amps). How much power does a car headlight take if it draws two amps at 12 volts?
    A. 2 Watts
    B. 12 Watts
    C. 24 Watts
    D. 48 Watts

12. True or False: The energy it takes to fabricate a photovoltaic panel is never recovered in its lifetime of use, so making PV panels is a net energy loser.

13. If a system costs $5 per peak Watt, and you need a peak capacity of 2kW, how much will your PV system cost?
    A. $10
    B. $1000
    C. $5000
    D. $10000
    E. $20000

14. If the system on average delivers 1/4 the peak power (day/night, seasons, weather), or 500 W average, how many kWh per day will you typically get?
    A. 500 kWh
    B. 0.5 kWh
    C. 12,000 kWh
    D. 12 kWh
    E. 24 kWh

15. At 12 kWh per day, and electricity at $0.15 per kWh, how much does your system save you on your electricity bill?
    A. about 12×$0.15 = $1.80 per month
    B. about 12×$0.15×30 = $54 per month
    C. about 12×$0.15×30 = $54 per year
    D. about 12×$0.15×365 = $657 per year

16. Let's say your system saves you $667 per year. How long to pay off the $10,000 investment?
    A. 6.7 years
    B. 10 years
    C. 15 years
    D. 20 years

17. Which capitalist society encourages solar entrepreneurs to sell excess electricity production and make money from their investment?
    A. The United States
    B. Germany
    C. The U.K.
    D. France
    E. Japan

18. If you decked out a typical car with 15% efficient PV panels, how much power (in horsepower) do you think you might muster from the sun?

    remember 1 hp ~ 750 W

19. What is wrong with the phrase: “consumes no more energy than a hairdryer?”
    A. a car produces motion, but a hairdryer heat
    B. neither consume energy: they just transform energy
    C. one is solar energy, the other electrical
    D. what they mean is power: energy from a hair dryer depends on time used
    E. I wouldn’t be caught dead driving a hair dryer around town

20. How short would you personally need the “payback” time to be before installing solar panels on your own roof?
    A. 1 year
    B. 3 years
    C. 5 years
    D. 10 years
    E. 20 years

21. How likely do you think it is that you will own a sizeable chunk of photovoltaic in your lifetime?
    A. not at all likely
    B. 15% likely
    C. 50% likely
    D. 85% likely
    E. practically certain

22. If, as a toy example, only 80% of incident light hits the black collector, 50% *of this stays* on the collector, and 75% *of this* makes it into the water, what is the net efficiency of heating the water?
    A. 30%
    B. 37.5%
    C. 40%
    D. 50%
    E. 75%

23. If you pay $1.50 per day for hot water, and a solar system costs $6,000, how long will it take to break even?
    A. 400 days ≈ 1 yr
    B. 600 days ≈ 1.6 yrs
    C. 4000 days ≈ 11 yrs
    D. 6000 days ≈ 16 yrs

24. What showering sacrifices would you *not* be willing to make?
    A. not shower every day
    B. shower in the afternoons after water is hot
    C. deal with water that’s less hot
    D. shorter showers
    E. intermittent use during shower

25. If each person in the U.S. is responsible for 10,000 W (10^4 W) of power, and there are 300 million people (3×10^8) in the U.S., and the U.S. uses 25% of the world power, what is the total global power production?
    A. 1.2×10^{12} W
    B. 3×10^{12} W
    C. 12×10^{12} W
    D. 30×10^{12} W

26. Since almost all human power production happens on land, but only 50% of the global photosynthetic process happens on land, which is bigger on land: human or plant power?
    A. human is way bigger
    B. human is bigger by a bit
    C. plant is bigger by a bit
    D. plant is way bigger

27. How much energy can be released if one cubic meter of water (mass 1,000 kg) drops 10 meters?
    A. 100 J
    B. 1,000 J
    C. 10,000 J
    D. 100,000 J
    E. 1,000,000 J

28. If each cubic meter of water in a 10 meter dam contains 100,000 J of gravitational potential energy, how much power is released by a 20 meter dam with a flow of 1,000 m^3/s?
    A. 100,000 J/s = 100 kW
    B. 200,000 J/s = 200 kW
    C. 100,000,000 J/s = 100 MW
    D. 200,000,000 J/s = 200 MW
    E. 2,000,000,000 J/s = 2 GW

29. Given numbers we covered from this lecture, what is the maximum hydroelectric contribution to our energy budget if 100% developed?
    A. 3%
    B. 6%
    C. 25%
    D. 50%
    E. we could get all of it this way

30. Let's say you've designed a wind farm capable of 800 MW of power production when the wind gets to 20 m/s. If the average wind available is 10 m/s, what is the average power achieved?
    A. 800 MW
    B. 400 MW
    C. 200 MW
    D. 100 MW
    E. 50 MW

31. S.D. has about 200 W/m^2 of both wind and solar. PV can get 10% easily; wind can get 1.5% area coverage, and 40% efficiency. Do you get more power by covering an acre with PV or wind turbines?
    A. wind does better, no question
    B. wind does slightly better
    C. solar does slightly better
    D. solar does better, no question

32. If solar is so much better than wind, why is wind growing so much faster than solar?
    A. It is cheaper to fill an acre of land with windmills than with PV
    B. Wind is more reliable: constant, even at night
    C. Government subsidies heavily favor wind
    D. The payback time for wind is shorter than for PV
    E. The average cost per kWh is cheaper for wind

33. Why is biomass considered exempt from CO_2 emissions regulations?
    A. because biomass does not emit CO_2 when burned
    B. because there is very little CO_2 involved
    C. because the CO_2 is borrowed and returned to the air
    D. because governments want to encourage development of biofuels, and not hamper with regulation
    E. because there is not enough of it presently to be a concern

34. Try to guess the efficiency of photosynthesis (as implemented in real plants).

    Pick a number in percent from 0 to 100%

35. If a corn field is 1.5% efficient, and an acre is about 4000 m^2, and the average insolation is 200 W/m^2, how much power does an acre of corn produce/store?
    A. 3 W/m^2
    B. 60 W
    C. 1200 W
    D. 12,000 W
    E. 800,000 W

36. If we harvest 80 QBtu of biomass today, and our budget is 100 QBtu, can we transition entirely to bio?
    A. Yes: if we just cut back a bit on expenditure
    B. Yes: we can probably ramp this up to 100 QBtu
    C. Maybe: seems too close to call
    D. No: we can't convert that 80 QBtu at high efficiency
    E. No: we would then starve for lack of food

37. At this point in the class, what is your take on the quantitative stress?
   A. I'm loving it: nice to have the tools
   B. It's a bit much, but I appreciate its utility
   C. Pretty ambivalent; as long as my grade is okay…
   D. It's more than I can handle, thus detracts from course
   E. It's a living nightmare for me

38. A neutron decays. It has no electric charge. If a proton (positive charge) is left behind, what other particle must come out if net charge is conserved?
   A. no other particles are needed
   B. a negatively charged particle must emerge as well
   C. a positively charged particle must emerge as well
   D. another charge will come out, but it could be either + or -
   E. neutrons cannot exist individually

39. If a neutron mass is 1.008665 amu, and the left-over kinetic energy after decay is 0.000841 amu, what percentage of the total mass-energy is left as kinetic energy?
   A. 8.4%
   B. 0.84%
   C. 0.084%
   D. 0.0084%
   E. 0.00084%

40. How many neutrons does ^{40}K have if potassium (always) has 19 protons?

41. If one of the neutrons in carbon-14 (carbon always has 6 protons) decays into a proton, what nucleus is left?
   A. carbon-13, with 6 protons, 7 neutrons
   B. carbon-14, but with 7 protons, 7 neutrons
   C. boron-14, with 5 protons, 9 neutrons
   D. nitrogen-14, with 7 protons, 7 neutrons
   E. nitrogen-15, with 7 protons, 8 neutrons

42. If a substance has a half-life of 30 years, how much will be left after 90 years?
   A. one-half
   B. one-third
   C. one-fourth
   D. one-sixth
   E. one-eighth

43. If you have a bone fragment that, when living, had one ^{14}C atom for every 100 million carbon atoms, how old is the bone if there is one ^{14}C for every 400 million carbons, if half-life is about 6,000 years?
   A. 6,000 years
   B. 12,000 years
   C. 18,000 years
   D. 24,000 years
   E. age cannot be inferred this way

44. What is the best summary of how a nuclear reactor works?
   A. radioactivity makes source hot (thermally), which boils water for steam
   B. radioactive decay products (electrons, mostly) are harnessed to produce electricity
   C. spare neutrons decay, releasing energy
   D. the fragment nuclei are together more massive than the original nucleus, and this mass change releases energy

45. If one gram of ^{235}U produces about 60 GJ of energy upon fission, a 1 GW plant goes through how many grams of ^{235}U per minute?
   A. about 0.1 grams
   B. about 1 gram
   C. about 10 grams
   D. about 100 grams
   E. about 1 kilogram

46. But if only a third of the thermal energy is converted into useful electricity, and the plant actually delivers 1 GW_e of electricity, how many grams per minute are used?
   A. still 1 gram per minute
   B. about 3 grams per minute
   C. about 10 grams per minute
   D. about 33 grams per minute
   E. I give up

47. At 3 grams per minute, and 1440 minutes in a day, about 4 kg of ^{235}U split in a day. If 100,000 kg of 4%-enriched uranium are loaded into the reactor, how long could the reactor run?
   A. 100 days
   B. 250 days
   C. 1000 days
   D. 2500 days
   E. 10,000 days

48. How long do you think our uranium supply would last if we went 100% nuclear, using conventional nuclear plants (the kind we use now)?
   A. 30 years
   B. 100 years
   C. 300 years
   D. 1000 years
   E. 3000 years

49. On a scale of 0 to 10, how much are you personally concerned about nuclear proliferation (10 means very worried)?

50. What are your thoughts on the nuclear fission road?
   A. we should expand: it's one of our only options
   B. expansion is almost guaranteed, given maturity of technology
   C. nuclear plants pose dangers to society: we should back away
   D. nuclear plants are fine, except for proliferation issues
   E. it is not a long-term solution, given the finite resource

51. Do you think we'll get to fusion?
   A. Yes: increased demand will produce results
   B. Yes: this *must* be in our future
   C. Yes: but perhaps not in my lifetime
   D. No: the challenges and poor record seem too daunting
   E. No: our energy resource and technological infrastructure will decline before we get there: we'll miss our chance

52. Of the currently viable alternatives to fossil fuels, which are you most enthusiastic about?
   A. solar
   B. wind
   C. nuclear fission
   D. biomass (wood; sugar ethanol: but not corn ethanol)
   E. hydroelectric

53. If gasoline has about 10 Calories per gram, and batteries have 0.02 Calories per gram, but are 5 times more efficient at delivering mechanical power, how much better is gasoline?
   A. 10/0.02 = 500 times
   B. 50/0.02 = 2500 times
   C. 10/0.1 = 100 times
   D. 50/0.1 = 500 times

54. If a 10 gallon tank of gas is 60 pounds, how much would a battery bank weigh if it had the same energy content, but was 50 times less efficient at storage?
   A. 3000 lbs
   B. 6000 lbs
   C. 600 lbs
   D. 300 lbs
   E. 60 lbs

55. So why don't we take the hydrogen plunge now?
   A. It's still too expensive compared to gasoline
   B. There is no infrastructure: no hydrogen fuel stations
   C. There are no natural supplies of hydrogen
   D. Hydrogen cars would be too expensive
   E. We would spend more energy making hydrogen than we would get back out: a net loss

56. What is your level of worry about our post-fossil fuel energy offerings?
   A. New technologies are no doubt going to save us
   B. There are plenty of options to chose from
   C. It's worse than I thought: disappointed that there are no obvious solutions
   D. We're looking at a crunch: we can't keep living the way we do now
   E. I'm really worried: it looks like nothing can replace F.F.

57. Where do you put yourself on the scale of global warming reality?
   A. unquestionably real/happening
   B. almost certainly happening
   C. divided: unsure what to think
   D. unlikely to be real
   E. a huge hoax with no reality

58. If the wiggles on the Keeling Curve are due to photosynthesis, in which season do you think it's at the high point of the wiggle?
   A. Northern hemisphere winter
   B. Northern hemisphere spring
   C. Northern hemisphere summer
   D. Northern hemisphere fall

59. If we have only spent half our recoverable fossil fuels at this point, how much higher should we expect the CO_2 level to climb if we use it all?
   A. it should saturate (stay the same) at today's value
   B. it will double: 380 → 760 ppm
   C. the pre-industrial level of 280 will double → 560 ppm
   D. it will rise another 100 ppm → 480 ppm
   E. there is no basis for extrapolation

60. If the earth gets hotter, the radiated power increases like T^4, thus removing heat. If it gets colder, the radiation decreases, losing less heat. What kind of feedback is this?
   A. positive feedback
   B. negative feedback
   C. positive in one case, negative in the other
   D. neither: there is no mechanism for feedback

61. Which of the following is an example of positive feedback?
   A. if the planet cools, the ocean absorbs more CO_2, meaning more thermal radiation escapes, cooling us more
   B. if the planet warms, more clouds form, rejecting incident sunlight, which has a cooling effect
   C. if a brick falls on a car's accelerator, the car accelerates, but the brick jerks back, easing off the accelerator

62. What should we do about global warming?
   A. nothing: business as usual
   B. burn fossil fuels faster to move on to alternatives quicker
   C. sequester CO_2 so we don't put any more into atmosphere
   D. drop our energy usage by a substantial amount
   E. scramble like mad to build renewable infrastructure

63. What do you think your energy future holds?
   A. We'll continue to support energy growth by one means or another
   B. We'll establish an equilibrium energy use at today's levels
   C. We'll establish equilibrium at today's level, but with renewables replacing fossil fuels
   D. We'll reduce energy use over concerns of global warming
   E. We'll see energy reduction imposed by declining fossil fuel supplies

64. What do you notice about the list of mitigation strategies in the Hirsch Report?
   A. hydrogen is not on the list
   B. biofuels (corn ethanol, biodiesel) are not on the list
   C. no new non-fossil resources on the list
   D. no nuclear or solar on the list
   E. no jet-packs or hovercars

65. What's the problem with all-fossil substitutes for oil?
   A. the carbon dioxide problem is not alleviated
   B. this is still a finite resource: we're back where we started
   C. it squeezes out renewable options
   D. cars would need to be re-fit to handle these alternative fuels
   E. no problem: let's do it

66. How significant do you think the impact of peak oil will be on your life?
   A. very little: my life will go on pretty normally
   B. somewhat: there will be a tight transition period
   C. moderate: things will never be *quite* as easy
   D. significant: it may impact my direction/choices
   E. substantial: the life we know today will be gone

67. If in ten years we face serious hardships, who are you likely to say is at fault?
   A. my own fault for not paying attention
   B. consumers for buying too much stuff
   C. corporations for their focus on short term profits
   D. the government for not stepping in in time
   E. nobody's fault: it's just the course of events

68. What do you think you'll do to mitigate the potential crisis?
   A. be more informed and engage in discussions
   B. reduce my own energy dependence
   C. prod my representatives to take this seriously
   D. vote with my dollars: support responsible companies
   E. probably nothing: not sure there is a need (or otherwise unmotivated)

69. What transportation options are you likely to pursue that has the biggest impact on our energy future?
   A. drive less often
   B. get a fuel efficient vehicle (e.g., hybrid)
   C. strive to live close to work to avoid commute
   D. walk, bike, or take public transportation
   E. fly less often

70. What lifestyle changes are you most likely to pursue to have an impact on energy?
   A. change my transportation
   B. take less frequent/less flow/less hot showers
   C. personally support solar or other alternative energies
   D. eat less meat and more organic food
   E. purchase fewer voluntary consumer goods