April 3, 2013

1. If you earn 7% interest (yeah, right!), what is the doubling time?

   (a) 3.5 years
   (b) 7 years
   (c) 10 years
   (d) 35 years
   (e) 70 years

2. At a 7% interest rate (problem before), how long before you have 8 times as much money in the bank?

   (a) 10 years
   (b) 20 years
   (c) 30 years
   (d) 40 years
   (e) 80 years

3. A jar is started with just enough bacteria that it will fill in exactly 24 hours, with a doubling rate of once per minute. If started at midnight, at what time will the jar be half full?

   (a) 12:00 noon
   (b) 8:00 PM
   (c) 11:00 PM
   (d) 11:30 PM
   (e) 11:59 PM

4. In the previous scenario of doubling every minute, the first jar filling at midnight, at what time will the three new (empty) jars be completely full, under the same growth rate?

   (a) at 12:02 AM
   (b) at 12:30 AM
   (c) at midnight the next day (24 hours later)
   (d) at midnight two days hence (48 hours later)
   (e) at midnight three days hence (72 hours later)

April 5, 2013

5. If you push a crate 3 m across the floor, exerting 200 N (about 45 lbs), how much energy does it take?

   (a) 200/3 = 67 N/m
   (b) 200 J

(c) 200 N·m

(d) 600 J

(e) 600 N·m

6. How much kinetic energy does a 1000 kg car have if traveling down a residential street at 10 m/s?

   (a) 5,000 J

   (b) 10,000 J

   (c) 50,000 J

   (d) 100,000 J

   (e) not enough information to say

7. If your mass is 50 kg, and you want to give yourself a kinetic energy of 100 J, how fast must you walk/run?

   (a) 1 m/s

   (b) 1.4 m/s (square root of 2)

   (c) 2 m/s

   (d) 4 m/s

   (e) 10 m/s

8. How much gravitational potential energy do you give your 1000 kg car when you drive it up a 1000 m mountain?

   (a) 1,000,000 J

   (b) 1,000,000 N·m

   (c) 10,000,000 J

   (d) 10,000,000 N·m

9. If you eat a 200 kilocalorie snack (about 800,000 J), and have a mass of 80 kg (with backpack, say), how high could you climb if you operated at 100% efficiency?

   (a) 1,000 m

   (b) 8,000 m

   (c) 10,000 m

   (d) This is why I don't like backpacking

10. How much energy does it take to heat a 1000 liter ($\sim$250 gallon) hot tub from 15 °C to 35 °C (hint: use 1 kcal $\approx$ 4,000 J)?

    (a) 1,000 J

    (b) 4,000 J

    (c) 80,000 J

(d) 4,000,000 J

(e) 80,000,000 J

11. If your house has 3600 kg worth of furniture, internal walls, appliances, air, etc., and you come back from vacation and have to heat your entire household by 10 °C, how much energy does it take (assume 1000 J/kg/°C)?

    (a) 3,600 J = 0.001 kWh

    (b) 36,000 J = 0.01 kWh

    (c) 3,600,000 J = 1 kWh

    (d) 36,000,000 J = 10 kWh

April 8, 2013

12. If you can put out 100 W of mechanical power, how long will it take you to push your 1000 kg car up to 2 m/s assuming all your energy goes into the car's kinetic energy, and not into fighting friction?

    (a) 10 seconds

    (b) 20 seconds

    (c) 40 seconds

    (d) 200,000 seconds

    (e) cannot determine answer from given information

13. How long will it take a 1000 W microwave to boil a coffee-mug (about 0.25 liters = 0.25 kg) of water, taking it from 20 °C to 100 °C (assume 4000 J/kg/°C)?

    (a) 1 s

    (b) 8 s

    (c) 10 s

    (d) 80 s

    (e) 320 s

14. If the average American requires 10,000 W of continuous power operating on their behalf, how much energy does an American use in a day?

    (a) 24 kWh

    (b) 240 kWh

    (c) 24,000 kWh

    (d) 240,000 kWh

    (e) 10,000 kWh

15. How much kinetic energy in a 10 m/s wind passes through a loop with a cross-sectional area of 1 m^2 in each second of time (pretend for calculational simplicity that air density is 1 kg/m^3)?

(a) 10 J

(b) 50 J

(c) 100 J

(d) 500 J

(e) 1,000 J

16. Pretending that there are 80,000 seconds in a day, and your diet is 2,000 kilocalories (about 8,000,000 J), how much power does your body run at?

(a) 10 W

(b) 50 W

(c) 100 W

(d) 1,000 W

(e) 10,000 W

17. How much more light power does a light bulb filament put out at 2000 °K compared to the same filament at 1000 °K?

(a) the same amount

(b) twice as much

(c) four times as much

(d) eight times as much

(e) sixteen times as much

April 10, 2013

18. A typical American is responsible for the expenditure of energy at a *rate* of 10,000 W. If there are roughly $\pi \times 10^7$ seconds in a year, about how many Joules does an American claim in a year?

(a) 3×10^8 kWh

(b) 3×10^8 J

(c) 3×10^{11} J

(d) (10 kW)×(24 hr/day)×(365 days/yr)

(e) (10,000 W)×(3600 sec/hr)×(24 hr/day)×(365 days/yr)

19. If you use 3×10^{11} J in a year, how much mass equivalent is this ($c^2 = 9 \times 10^{16}\,\mathrm{m}^2/\mathrm{s}^2$)?

(a) 3×10^{-6} kg = 0.003 mg

(b) 3×10^{-3} kg = 3 mg

(c) 3 kg

(d) 27×10^{25} kg

20. We saw in the fusion example that turning hydrogen into helium reduced the total amount of mass from 4.029 units to 4.0015 units. When the mass is reduced, what does this imply about fusion of hydrogen to helium?

    (a) it is energetically favorable, meaning that energy will be released
    (b) it is energetically disadvantaged, and requires a net input of energy
    (c) the masses all add up properly, if you count other masses that emerge
    (d) mass differences alone do not have anything to do with energy balance

21. At the high end of the periodic chart, atoms have masses of about 1.0002 grams per mole of nucleons (neutrons plus protons), while stuff in the middle of the chart (like iron) weigh 0.9988 grams per mole of nucleons. What does this say about the energetic favorability of fission versus fusion at the upper end of the periodic table?

    (a) lighter things like iron are energetically encouraged to fuse into heavier elements
    (b) heavier things are energetically encouraged to fission into lighter elements
    (c) the measured masses have no bearing on fission/fusion preference
    (d) the difference is more than made up by the masses of electrons, so nothing here

22. If I pull a large pendulum back so that its height above the bottom of its swing is 0.5 meters, how fast will it travel at the bottom?

    (a) need to know the mass to proceed
    (b) 1 m/s
    (c) 3 m/s (= $\sqrt{10}$)
    (d) 4.5 m/s (= $\sqrt{20}$)
    (e) 20 m/s

23. Why are the numbers for earth radiation balanced perfectly against input solar energy?

    (a) if it were not, earth would not be habitable
    (b) it's just a coincidence
    (c) it's guaranteed: hotter earth radiates more
    (d) it's a stable equilibrium point

    April 12, 2013

24. About what fraction of global energy do you think comes from fossil fuels today?

    (a) 20–25%
    (b) 55–60%
    (c) 65–70%
    (d) 80–85%
    (e) 90–95%

25. Which of our industrial forms of energy do not trace back to our own sun?

    (a) coal-fired power plants
    (b) petroleum products
    (c) wind energy
    (d) solar photovoltaic energy
    (e) nuclear energy

26. The United States has about 4.5% of the world's population. How much of the world's energy resource do we use?

    (a) 3%
    (b) 5%
    (c) 12%
    (d) 20%
    (e) 50%

27. What, if anything, caught your eye about the previous plot on renewables?

    (a) hydroelectric hasn't grown since about 1970
    (b) wood is still more important for energy than biofuels or wind
    (c) more wood is used today for energy in the U.S. than during 1950–1975
    (d) wind and biofuels are climbing fast
    (e) solar (part of "other") isn't taking off like wind and biofuels

April 17, 2013

28. How likely do you think it is that if you drill straight down at a random spot on the planet, you'll hit oil?

    (a) 0.01%
    (b) 0.1%
    (c) 1%
    (d) 10%
    (e) 50%

29. If one tank of gas is 10 gallons, and each gallon is 6 lbs (75% density of water), then how much CO_2 does a fill-up put out?

    (a) 6 lbs
    (b) 18 lbs
    (c) 60 lbs
    (d) 180 lbs

(e) 600 lbs

30. If you (as an average U.S. citizen) are responsible for 50 barrels of fossil fuels per year, and one barrel contains 250 lbs of oil, how much CO_2 are you responsible for per year?

    (a) 250 lbs
    (b) 1250 lbs
    (c) 3,750 lbs
    (d) 12,500 lbs
    (e) 37,500 lbs

31. Complete the (paraphrased) quote from a prominent politician: "A nation that owns 3% of the oil resource while using nearly a quarter of the world's oil resource...

    (a) ...had better get its but in gear and find more domestic oil
    (b) ...is not going to drill its way out of the problem
    (c) ...has only one thing to do: drill, baby, drill
    (d) ...had best take control of the "glittering prize" that is the Middle East
    (e) ...must be prepared for military seizure of vital petroleum assets overseas

32. U.S. oil production has declined to 60% of its peak. Why?

    (a) Foreign oil is cheap enough: little incentive to drill our own
    (b) Labor laws won't let us get at the oil fast enough
    (c) Most of the oil is locked up in protected sites
    (d) The supply is being pumped dry
    (e) Our reliance on oil is not as great as it was at peak

33. What do you think the world's oil companies have been doing over the last decade?

    (a) exploring like mad to discover more oil
    (b) building more refineries to handle our ever-increasing consumption
    (c) building more tankers to transport oil
    (d) controlling production rate to control prices
    (e) gobbling each other in "last one standing" merger game

April 19, 2013

34. Where will a declining petroleum production have the most substantial impact?

    (a) in the residential sector
    (b) in the industrial sector
    (c) in the electricity production sector
    (d) in the transportation sector

(e) it will not have a significant impact

35. When looking at the future of natural gas resources, we only consider the domestic/North-American portion. Why?

    (a) OPEC will not sell us their natural gas
    (b) foreign natural gas is a different composition: would not work in our devices
    (c) other nations don't provide estimates of their resource
    (d) it's routed by pipes, not tankers

April 22, 2013

36. Which of the following best describes heat?

    (a) energy storage
    (b) ordered kinetic energy on the molecular scale
    (c) another form of potential energy
    (d) disordered kinetic energy on the molecular scale
    (e) useless by-product of energy conversion processes

37. What do you think is a physicist's objection to using the second law of thermodynamics (increasing entropy) to argue against evolution?

    (a) science should not be used in religious arguments
    (b) the sun is usually not included in such arguments
    (c) entropy can decrease locally, if it increases more elsewhere
    (d) it's nearly impossible to measure entropy
    (e) physics does not apply to the real world

38. Wait a minute: if heat flows out, shouldn't T_h decrease according to $\Delta Q = c_p m \Delta T$? What do you think my answer is?

    (a) the hot source has a huge specific heat capacity (c_p): much bigger than the usual 1000 J/kg/°C
    (b) the hot source has huge bulk (m)
    (c) this type of heat flow does not constitute energy flow
    (d) we're going to keep ΔQ small, so ΔT will be small

39. What is the maximum efficiency one could get using liquid water to drive a heat engine (not under pressure)?

    (a) 0/100 = 0%
    (b) 100/373 = 27%
    (c) 100/273 = 37%

(d) 273/373 = 73%

(e) 100/100 = 100%

40. If I have a heat engine operating between 327 °C and 27 °C, what is the maximum efficiency allowed by thermodynamics?

(a) 27/600 = 4.5%

(b) 27/327 = 8.3%

(c) 300/600 = 50%

(d) 300/327 = 92%

(e) 100%

April 24, 2013

41. A heat pump keeps a house at 17 °C while it is -3 °C outside. What is the maximum possible coefficient of performance?

(a) 17/20 = 85%

(b) 270/20 = 13.5

(c) 290/20 = 14.5

(d) 17/270 = 6%

(e) 100%

42. Which is the most efficient way to heat a home?

(a) Space heaters (electric coils)

(b) Natural gas furnace

(c) Heat pump

(d) a toss-up between (b) and (c)

(e) Run your clothes dryer with the door open

43. How efficient would you guess our electricity distribution system is, on average?

(a) 10%

(b) 50%

(c) 90%

(d) 98%

(e) 100%

44. What do nuclear, geothermal, coal, natural gas, and hydro electricity all have in common, besides the fact that we use them to generate electricity?

(a) they all ultimately come from our own Sun

(b) all are essentially fossil fuel sources

(c) all contribute substantially to global warming

(d) all produce electricity via turbines and generators

(e) all are heat engine implementations

45. Why is it important to keep voltages low-ish in houses?

(a) Appliances are made to run on lower voltage

(b) Appliances waste less energy if run at lower voltage

(c) Safety: higher voltage would be more dangerous, cause more fires/injury

(d) Historical accident: Tesla won battle with Edison

(e) Don't know what to pick

46. Why, then, do we insist on transmitting electrical power at high voltage?

(a) Generators naturally put out high voltage; hard to change it

(b) Transmission is far more efficient at high voltage, which means lower current

(c) Safety: high voltage transmission is less accident-prone

(d) Cheaper: the structures needed to carry high-voltage wires are smaller than for low-voltage

(e) Because AC power gives us that choice: Tesla won

April 26, 2013

47. How much energy is consumed by a space heater running at 1500 W for four hours straight?

(a) 1.5 kWh

(b) 6.0 kWh

(c) 1500 kWh

(d) 6000 kWh

(e) ill-posed question: answers above are in wrong form

48. How much energy does a bath take if we heat 40 gallons of water by 50 °F at 100% efficiency? Use 8 pounds per gallon, and definition of Btu (raise 1 lb water by 1 °F).

(a) 200 Btu = 0.002 Therm

(b) 1600 Btu = 0.016 Therm

(c) 2000 Btu = 0.02 Therm

(d) 16000 Btu = 0.16 Therm

(e) conversions are killing me!

49. What do you think is the explanation for the mismatch in gas usage?

(a) Calculations are wrong, dude. 60 °F? Gimme a break

(b) The water heater is probably only 20% efficient

(c) You did not account for pilot lights

(d) There is a gas leak, or the meter is wrong

(e) A band of monkeys use your shower during the day

April 29, 2013

50. From 1994 to 2003, what do you think our use of renewable energy did?

(a) went up

(b) went down

(c) stayed the same

(d) no opinion/guess

51. Which renewable resource would you guess grew the most (in terms of delivered energy) in the last ~10 years?

(a) hydroelectric

(b) geothermal

(c) biomass

(d) solar

(e) wind

52. 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

53. 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 judgment

54. 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

55. The best place for solar in the U.S. is the southwest desert. The worst is the Olympic Peninsula. By what factor do you think the desert beats the Pacific NW, in terms of annual solar energy deposited?

    (a) a factor of two

    (b) a factor of four

    (c) a factor of five

    (d) a factor of ten

    (e) more than a factor of ten

56. Why is the annual (diffuse) energy map different from the concentrating solar power map?

    (a) they really aren't different

    (b) humidity is the main factor

    (c) mainly due to clouds vs. full sun

    (d) relates to efficiency for getting rid of waste heat

57. 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

Answer key: 1. c; 2. c; 3. e; 4. a; 5. d OR e; 6. c; 7. c; 8. c OR d; 9. a; 10. e; 11. d; 12. b; 13. d; 14. b; 15. d; 16. c; 17. e; 18. c OR e; 19. a; 20. a; 21. b; 22. c; 23. c OR d; 24. d; 25. e; 26. d; 27. ALL?; 28. a; 29. d; 30. e; 31. b; 32. d; 33. e; 34. d; 35. d; 36. d, e sometimes; 37. c OR d; 38. b; 39. b; 40. c; 41. c; 42. usu. c, sometimes b (dep. on source of elec.); 43. c; 44. d; 45. c; 46. b; 47. b; 48. d; 49. c; 50. b; 51. c; 52. d OR e; 53. c; 54. b; 55. a; 56. c; 57. d