19. Growth rate of 0.5%, then doubling time T2 = 69/0.5 = 138 years. So from today's population one doubling would be around $14*10^9$.

Chapter 2

1. m = 0.5 kg, v = 5 m/s

$E_k = 0.5*m*v^2 = 0.5*0.5*(5)^2 = 6.25 \text{ kg } (m/s)^2 = 6 \text{ J}$

The kinetic energy is converted into thermal energy.

2 I have 13, 100 W bulbs and 5, 60 W bulbs.
Power is 13*100 W = 1.3 kW and 5*60 = 0.3 kW. Total power = 1.6 kW
Average usage, 8 hrs/day
Energy = P*t = 1.6*8 = 12.8 kWh/day
The total energy for the lighting for year is 12.8*365 = 4700 kWh.

3. Compact fluorescent lights, equivalent light output; 13, 25 W blubs, and 5, 15 W blubs/
Power is 13*25 = 325 W and 5*15 = 75 W. Total power is 0.4 kW.
Energy = P*t = 0.4*8 = 3.2 kWh/day
Energy/year = 3.2*365 = 1190 kWh/yr.
Savings = 4700 - 1190 = 3510 kWh.
Also compact fluorescent lights last longer.

4. Answers will vary by student. Check labels for power. Also P = Volts*Amps
Device watts can also be found at http://michaelbluejay.com/electricity/howmuch.html.
Answers will vary from 10-30 kW, dependent on how many uses there are. My approximate maximum power for my home is around 25 kW.

use	power, kW
lights (from problem 2)	1.6
air conditioner	3.5
water heater	3.8
refrigerator	0.2
TVs, 3	0.8
computer, 2	0.4
hair dryer	1.5
washing machine	1.0
dryer	4.0
dishwasher	1.2
disposal	0.2
stove electric	2.3
microwave	1.4
miscellaneous electric tools	2.0
	24

5. Answers will vary by student. My electric use was around 800 kWh/month. An all electric home will be higher.

6. What is the power rating of your vehicle (convert horsepower to KW)? What is the fuel efficiency (miles/gal or km/liter)?
Honda Accord Hybrid, gas motor, 253 hp = 190 kW, electric motor = 12 kW, fuel economy = 28 mpg (highway long trips, 34 mpg).
Dodge Grand Caravan, 215 hp = 161 kW, 18 mpg (highway long trips, 24 mpg)

7 Average fuel efficiency in U.S = 24 mpg. Increase efficiency to 35 mpg
U.S. oil consumption 7.3 Gbbls/yr, imports = 60%, so imports = 4.4 Gbbls/year.
Approximately 45% of oil in U.S. used for vehicles.
So for imported oil, vehicle use = 4.4*0.45 = 2 Gbbls/yr
Use would be reduced to (24/35)*2 = 1.4 Gbbls/yr
Oil savings would be 2 – 1.4 = 0.6 Gbbls/yr.
\$ savings = \$80*0.6*10^9 = \$48*10^9/yr.

8. Assume fuel efficiency is 50 mpg
Same as previous problem
Use of imported oil = (24/50)*2*10^9 = 1*10^9 bbls
Oil savings would be 2 – 1 = 1*10^9 bbls.
\$ savings = \$80*1*10^9 = \$80*10^9/yr.

9. T_H = 30 deg C, T_C = 10 degrees C. T(°k) = T(°c) + 273
T_H = 303 deg K, T_C = 283 deg K
Maximum theoretical efficiency

$E = (T_h - T_c)/T_h = 20/303 = 6.6\%$

10. From one web site the different numbers for energetics range from 1.38:1, 2.09:1, 2.51:1 2.63:1

11. Efficiencies of fuel cells around 80%; combined cycle gas turbines around 60%.

12. The main source of light in the Middle East is flaring (burning natural gas) as by product of oil production.

13. Fossil fuels include coal, oil, and natural gas, so around 86% of world energy is from fossil fuels.

14. Estimated year for peak production of coal: U.S., 2030's; China, 2015-2020; world, 2025.

15. Population = 200,000; R = 10% per year.
Doubling time, $T_2 = 69/R$
$T_2 = 69/10 = 7$ years; 5 doubling time so in only 35 years, popuation would be
200,000; 400,000; 800,000; 1,600,000, 3,200,000, 6,400,000 or
amount = 2^5 = 32 times.
Population after 35 years = 32* 200,000= 6.4*10^6.
Just think of the infrastructure problems of taking care of 6,200,000 people in 35 years.

16. Population, $r_o = 6.8*10^9$, rate of growth of population = 1% per year.
Population in 2050, k = 0.01/yr, t = 40 years, k*t= 0.01*40 = 0.4

$r = r_o e^{kt}$

$r = 6.8*10^9*e^{0.4} = 6.8*10^9*1.5 = 1.0*10^{10}$

Could do problem in spreadsheet, multiply population of each year by 0.01 and then add.

yr	Amount	Increase
1	6.8	0.068
2	6.9	0.069
39	9.9	0.099
40	10.0	0.100

17. Population, $r_o = 6.8*10^9$, rate of growth of population = 0.5% per year, $r = 10*10^9$.

$r = r_o e^{kt}$

$r/r_o = e^{kt}$, take ln of both sides

$k*t = \ln(r/r_o)$

$t = (1/k)*\ln(r/r_o)$

$t = (1/0.005)*\ln(10*10^9/6.8*10^9) = 200*0.38 = 77$ years.

Could do problem in spreadsheet, multiply population of each year by 0.005 and then add. See how many years it takes to get to $10*10^9$.

18. r_o = 1100 GW, time = 50 years, k = 0.07. kt = 0.07*50 = 3.5

$r = r_o e^{kt}$

$r = 1100*e^{3.5} = 1100*33 = 36{,}300$ GW

New plants, need 36,300 – 1,100 = 35,200 GW

The most economical size of nuclear power plants is around 1 GW.
So would need 35,200 new nuclear power plants over 50 years.

19. Same as problem 17, except size of coal plant is around 400 MW. Would have to build 35,200,000/400 = 88,000 new coal plants in U.S over the next 50 years

20. At \$3000/kW, a 1000 MW nuclear power plant would cost $\$3*10^9$.
Total cost for nuclear plants = $3.5*10^4*3*10^9 = \$10*10^{13}$.
For same total power, coal would be half, $\$5*10^{13}$.

21. r_o = 1100 GW, time = 40 years, k = 0.06. kt = 0.05*40 = 2, operational 95%.

$r = r_o e^{kt}$

$r = 1100*e^2 = 1100*7.4 = 8100$ GW

Average operational power = 0.95*8100 = 7700 GW.
Electric energy for 1 year = 7700 GW*7280 hr = $5.6*10^7$ GWh or $5.6*10^7$ EWh.
energy in coal, 1 metric ton = 7326 kWh = 7.3 MWh.
The efficiency of conversion is 35%. 1 metric ton converts to = 2.6 MWh
Metric tons of coal needed for one year = $5.6*10^{10}$ MWh /2.6 MWh = $2.1*10^{10}$ metric tons.
How many years would U.S. coal reserves last at that rate of consumption?

22. T_H = 700 °C, T_C = 310 °C.

$T(k) = T(C) + 273$, $T_H = 973$ °K, $T_C = 583$ °K
$E = (T_H - T_C)/T_h = 390/973 = 40\%$

23. U.S. coal reserves: $243*10^9$ metric tons
U.S. coal consumption in 2006 is $1112*10^6$ short tons
1 short ton = 0.907metric ton, so consumption is $1*10^9$ metric tons/yr.
Time = reserves/consumption = $243*10^9/1*10^9$ = 243 years.

24. $S = 243*10^9$ metric tons, $r_0 = 1*10^9$ metric tons, $k = 0.1$/yr
Use Eq. A.3

$$T_E = \frac{1}{k}\ln\left(k\frac{S}{r_o} + 1\right)$$

$T = (1/.1)\ln(0.1*243 + 1)$
$T = 10*\ln(25) = 10*3.2 = 32$ years

Another way is to use spreadsheet and calculate increase by year and cumulative consumption.
Or use doubling time and find out what period all the reserves will be used.
10% growth is a doubling time of 7 years.

Now	$1*10^9$	$1*10^9$
7 yr	$2*10^9$	$10*10^9$
14 yr	$4*10^9$	$31*10^9$
21 yr	$8*10^9$	$63*10^9$
28 yr	$16*10^9$	$135*10^9$
35 yr	$32*10^9$	$305*10^9$

so between 28 and 35 years, all the reserves will be used.

25. My electric and heating bill is around \$1400/yr, so I would save \$700/yr.

26. For world, $S = 175*10^{12}$ m^3, world consumption (2008, www.eia.doe.gov) = $110*10^{12}$ cubic ft. 1 cubic ft = 0.0283 m3. $C = 3.1*10^{12}$ m^3.
Time = S/C = 175/3.1 = 56 years.

27. World uranium oxide, $S = 5*10^6$ metric tons
World consumption, C = 70,000 metric tons/yr

Time = S/C = $5*10^6$/70,000 = 70 years.

28. $S = 5*10^6$ metric tons, r_0 = 7*104 metric tons, k = 0.07/yr
Use Eq. A.3

$$T_E = \frac{1}{k}\ln\left(k\frac{S}{r_o} + 1\right)$$

$T = (1/0.07)\ln(0.07*70 + 1)$
$T = 14*\ln(11) = 14*2.4 = 34$ years

29. Projected population = $11*10^9$, population in 2010 = $6.8*10^9$.
Increase = $11*10^9 - 6.8*10^9 = 4.2*10^9$.
Mexico City population = $2*10^7$.
Number of cities = $4.2*10^9/2*10^7 = 200$.

30. Assume that 2 cars/person in China (same as in U.S.), so there would be 2.6 billion cars in China. Assume average fuel efficiency = 40 mile/gal and every car drives 40 miles/day, so
$C = 2.6*10^9$ gal/day or $9.5*10^{11}$ gal/year.
1 bbl produces around 22 gal gasoline.
$C = 4.3*10^{10}$ bbls/yr.
World oil production is around $3.0*10^{10}$ bbl/yr, so China would be using all the world oil production.

31. Turn off the lights during daytime.
Reduce driving time, make less short trips.
Use bicycle for other short trips.
Turn off the heater in winter during daytime.
Change thermostat settings, lower in winter, higher in summer.
Use ceiling and floor fans.
Drive 65 mph or interstate highways. For those states lower maximum speed limit on interstate, drive 5 mph below maximum.

Chapter 3

1. Around the length of your arm, 40 cm, to block the moon.

2. Date: Feb. 5th Canyon, TX; Lat: 35 N, Lon: -102
Sunrise, Azimuth 110°, Elevation 0°
Solar noon, Azimuth 180°, Elevation 40°
Sunset, Azimuth 250°, Elevation 0°

3. Date: Feb 5th Canyon, TX; Lat: 35 N, Lon: -102
Sunrise, about 20 deg south of East
On March 21 and September 21, sunrise is due east, and sunset is due west.

4. Inside of car is quite a bit hotter than outside, by 5 ^{o}C or more.

5. Protons are converted into helium nuclei and energy, because the mass of helium is less than the mass of the protons, that difference in mass (around $5*10^9$ kg/s) is converted into energy.
Speed of light, $c = 3*10^8$ m/s.
$E = mc^2$ and $P = E/t$
$P = (m/t)*c^2 = 5*10^9*(3*10^8)^2 = 45*10^{25}$ kg $(m/s)^2/s = 4.5*10^{36}$ W