Chapter 2

1. m = 0.5 kg, v = 10 m/s
$E_k = 0.5*m*v^2 = 0.5*0.5*(10)^2 = 25 \text{ kg (m/s)}^2 = 25 \text{ J}$
The kinetic energy is converted into thermal energy.

2. I have 20, 100 W bulbs and 10, 60 W bulbs.
Power is 20*100 W = 2 kW and 10*60 = 0.6 kW. Total power = 2.6 kW
Average usage, 6 hrs/day
Energy = P*t = 2.6*6 = 16 kWh/day
The total energy for the lighting for year is 16*365 = 5800 kWh.

3. Compact fluorescent lights, equivalent light output; 20, 25 W blubs, and 10, 15 W blubs/
Power is 20*25 = 0.5 kW and 10*15 = 0.15 W. Total power = 0.75 kW
Energy = P*t = 0.75*6 = 4.5k Wh/day
Energy/year = 4.5*365 = 1600 kWh/yr.
Savings = 5800 - 1600 = 4,200 kWh.
Also compact fluorescent lights last longer. Now LED lights are available, which are more efficient than CFL.

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 30 kW.

use	power, kW
lights (from problem 3)	0.8
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
electric vehicle	6.6
	30

5. Answers will vary by student. My electric use was around 900 kWh/month, that includes electric vehicle which is around 200 kWh/mo. 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)?

Hyundai Sonata Hybrid, gas motor, 199 hp = 149 kW; electric motor = 35 kW; fuel economy = 37 mpg; battery 1.6 kWh.
Nissan Leaf, 80 kW motor, 24 kWh battery. Drive around 800 mi/mo, use 210 kWh/mo.
Performance; 3.7 miles/kWh, which is equivalent to 120 mpg. Rating by Nissan was 106 mpg.

7 OM: Average fuel efficiency in U.S = 24 mpg. Increase efficiency to 35 mpg
2014 data, EIA. U.S. oil consumption 6.9 Gbbls/yr, imports = 1.85 Gbbls/year.
Approximately 45% of oil used for vehicles.
So for imported oil, vehicle use = 1.85*0.45 = 0.9 Gbbls/yr
Use would be reduced to (24/35)*0.9 = 0.6 Gbbls/yr
Oil savings would be 0.9 – 0.6 = 0.3 Gbbls/yr.
2014 oil average price \$98/bbl. Savings = $\$98*0.3*10^9 = \$29*10^9$/yr.
Jan-Jul 2014 oil average price = \$59/bbl. So savings at low oil price would still be significant, $\$15*10^9$/yr.

8. Assume fuel efficiency is 50 mpg
Same as previous problem
Use of imported oil = $(24/50)*0.9*10^9 = 0.4*10^9$ bbls
Oil savings would be $0.9 – 0.4 = 0.5*10^9$ bbls.
\$ savings = $\$98*0.5*10^9 = \$46*10^9$/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. 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 77% of world energy is from fossil fuels (Fig. 2.3).

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

15. OM: Population = 100,000; 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
100,000; 200,000; 400,000; 800,000, 1,600,000, 3,200,000 or
amount = $2^5 = 32$ times.
Population after 35 years = $32* 100,000= 3.2*10^6$.
Just think of the infrastructure problems of taking care of an additional 3,100,000 people in 35 years.

16. OM: Population, $r_o = 7.3*10^9$, rate of growth of population = 1% per year.

Population in 2050, k = 0.01/yr, t = 35 years, k*t= 0.01*35 = 0.35

$r = r_o e^{kt}$

$r = 7.3*10^9*e^{0.4} = 7.3*10^9*1.4 = 1.0*10^{10}$

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

yr	Amount	Increase
1	7.3	0.073
2	7.4	0.074
34	10.1	0.101
35	10.2	0.102

17. OM: Population, $r_o = 7.3*10^9$, 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

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

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

$t = (1/0.005)*\ln(10*10^9/7.3*10^9) = 200*0.31 = 63$ 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. OM: $r_o = 1100$ 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. OM: At $5000/kW, a 1000 MW nuclear power plant would cost $\$5*10^9$.

Total cost for nuclear plants = $3.5*10^4*5*10^9 = \$18*10^{13}$.

Coal plants = $3.5*10^4*1.5*10^9 = \$5*10^{13}$.

20. OM: Answers can vary due to start date, but OM answer should be around the same value. We used 2015.

U.S. coal plants: Generated around 33% of US electricity, installed coal capacity 296 GW (data from eia.gov, 2013) capacity factor 95%, efficiency of coal to electricity is 0.35%.

1 short ton coal contains $28*10^6$ Btu. 1 metric ton = 1.1 short ton

Coal supplied electric generation. Declining because of increase in renewables and natural gas.

2013 39%

2015 33% 16.5 Quad or $16.5*10^{15}$ Btu

So coal used for electricity production = $16.5*10^{15}$ Btu/($2.8*10^7$ Btu short ton) = $6*10^8$ short tons.

Coal consumption = $0.9 * 6*10^8 = 5*10^8$ metric tons.

Similar to problem 18, except size of coal plant is around 400 MW or 0.4 GW and growth rate = 0.5.

$r_o = 5*10^8$, time = 35 years, k = 0.05. kt = 0.05*35 = 1.75

$r = r_o e^{kt}$

$r = 5*10^8 * e^{1.75} = 5*10^8 * 5.75 = 3*10^9$ metric tons/yr.

Note that is a production that 6 times larger than in 2014.

Again could use spread sheet to estimate production for 2050.

Side note: China is building around 200 coal plants per year to help meet increasing electric demand.

21. $T_H = 700$ °C, $T_C = 310$ °C.

$T(k) = T(C) + 273$, $T_H = 973$ °K, $T_C = 583$ °K

$E = (T_H - T_C)/T_h = 390/973 = 40\%$

22. OM: U.S. coal reserves: $237*10^9$ metric tons (Table 2.1).
U.S. coal consumption in 2013 is $985*10^6$ short tons. Around 90% for generating electricity.
1 short ton = 0.907 metric ton, so consumption is $893*10^6$ metric tons/yr.
Time = reserves/consumption = $237*10^9/983*10^6$ = 240 years.

23. OM: S = $237*10^9$ metric tons, $r_0 = 0.89*10^9$ metric tons, k = 0.1/yr
Use Eq. A.3

$S/ r_0 = 237*10^9/0.89*10^9 = 266$

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

$T = (1/.1)\ln(0.1*266+ 1)$

$T = 10*\ln(28) = 10*3.3 = 33$ 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.

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

25. OM: For world, S = $186*10^{12}$ m^3, world consumption (2013, www.eia.doe.gov) = $3,424*10^9$ cubic m.

Time = S/C = 186/3.4 = 58 years.

26. OM: World uranium oxide, S = $5*10^6$ metric tons

World consumption, C = 66,000 metric tons/yr

Time = S/C = $5*10^6/66{,}000$ = 75 years.

27. OM: S = $5*10^6$ metric tons, r_0 = $6.6*10^4$ 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*76 + 1)
T = 14*ln(6.3) = 14*1.8 = 26 years

Or could use spreadsheet and find approximate year range for use of resource.

28. Projected population = $11*10^9$, population in 2015= $7.3*10^9$.
Increase = $11*10^9 - 7.3*10^9 = 3.8*10^9$.
Mexico City population = $2*10^7$.
Number of cities = $3.8*10^9/2*10^7$ = 190.

29. 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.

30. World oil production is around 30 Gbbls/yr (2014 data).

Country	million bbl/day
US	14.0
Saudi Arabia	11.6
Russia	10.9
China	4.57
Canada	4.38

31. World natural gas production (2014 data) = $3{,}387*10^9$ cubic m.

32. 2014 data, world coal production (2014 data) = $7.8*10^9$ metric tons

33. World nuclear power plants = 442 (Mar 2016). U.S. nuclear power plants = 99. Generates 20% of U.S. electricity.
In 2014 there were 103.

World

	New connection	Permanent Shutdown
2015	10	8

2014	5	1
2013	4	6
2012	3	3
2011	7	13
2010	5	1
total	34	32

34. Ways to say energy.
Turn off the lights during daytime.
Reduce driving time, make less short trips.
Use bicycle for other short trips.
Change thermostat settings, lower in winter, higher in summer.
Use ceiling and floor fans.
Drive 65 mph on interstate highways. For those states that now have 65 mph speed limits (primarily in the Eastern U.S. should lower maximum speed limit on interstate to 60 mph, drive 5 mph below maximum. Texas has increased speed limit on many of its highways to 75 mph and a few sections to 80 mph.

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. 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

5. Amount of solar radiation   Sun changes luminosity
Amount of radiation reflected   More clouds, more ice, paint all rooftops white
Amount absorbed in atmosphere, then proportions back to earth and to space.
Heating; greenhouse gases in the atmosphere.
Cooling; aerosols, remove carbon dioxide from atmosphere

6. Answer will vary by student. This was for a Chinese student. Date: April 02.
Lat: 31.8 N: Lon: 117.3 E
Sunrise: altitude: 0°, azimuth: 71.7°
Sunset: altitude: 0°. azimuth: -71.58°
Solar noon: altitude: 42.14°, azimuth: 0