Energy and Society

Exam 2
1. (5pts) Given the extremely low efficiency of automobiles, there is some interest worldwide on replacing the metal parts of cars with carbon fiber composites to make them lighter. With respect to **automobile manufacturing**, carbon fibers are
   a. **being considered for use in Europe**
   b. being considered for use in USA
   c. used widely in the USA and Europe
   d. used widely in China, USA, and Europe
   e. not ready yet to be implemented into automobile production

2. (5pts) The **most environmentally harmful emissions from automobiles** are
   a. CO, SO₂, and particulates
   b. hydrocarbons, CO, and SO₂
   c. CO, particulates, and NOx
   d. CO₂, SO₂, and NOx
   e. CO, SO₂, and NOx

3. (5pts) Given a Nucleus A (Z+N) with Z protons and N neutrons. Indicate what are the number of protons, neutrons, and A for the remaining nucleus after **beta minus decay**.
   a. Z+1, N-1, A
   b. Z-1, N+1, A
   c. Z, N, A
   d. Z, N-1, A-1
   e. Z-2, N-2, A-4
4. (10 pts) Briefly describe each of the three nuclear accidents or mishaps. What is/are some suggestions on regulating the nuclear energy industry?

Three Mile Island
Chernobyl
Fukushima

...global regulation of the nuclear industry...global regulation of radioactive waste disposal.

5. (10pts) How does a hydrogen fuel cell work? What are the major components?

\[ H_2 + O_2 \text{ Makes electricity and } H_2O \]

Cathode/anode/membrane/catalyst

6. (10pts) The newly discovered resources of natural gas are often in the news these days. The figure below shows the reserves by state: Most of it is shale gas. Briefly describe what is shale gas and the method by which it is extracted from the reserves. The benefits of a domestic supply of natural gas are obvious. What are some of the risks?

7. (12pts) The two figures below show examples of a Boiling Water (BWR) and a Pressurized Water (PWR) nuclear reactor. Please Compare and Contrast for the BWR, PWR, Liquid breeder, and a fusion reactor.

- the sources of nuclear energy
- the electricity generation mechanism
- the specific operation or working characteristics
8. **(20pts)** The human body on the average contains about 18% carbon and 0.27% potassium. Compute the activity of the average person from 40K. Potassium is very important in brain and nerve function. (Assume the mass of an average human is 70 kg and that 0.012% of potassium is 40K. The half-life of the one of 40K is 1.28 billion years. What is the **absorbed dose of a person** in an average lifetime of 72 yrs from this internal exposure if each decay releases an average energy of 0.5MeV of beta and gamma radiation? **What is the exposure?** Mol. Weight of 40K is 40.
9. (13pts) What is the thermohaline circulation? What makes it work? Discuss what determines the density of water. What are some consequences of temperature change on thermohaline circulation?

The driving force are wind driven drag forces, turn-over points are the thermohaline downwelling event in the Northern Atlantic Ocean, and the corresponding upwelling, based on gradual warming of water and coastal conditions in the Indian and Northern Pacific Ocean. The actual flow pattern shows significantly more complex structure.
Shut-Down of Conveyor Belt
due to rapid decline of salinity in Arctic waters
11. (10pts) On a recent excavation, the remains of a human were found in a cave. The analysis of the $^{14}$C content showed that it was 45% of what is found in living organisms today. How old are the remains? The half-life of $^{14}$C is 5730 yrs.

\[ N = N_0 e^{-\lambda t} \]

\[ \frac{N}{N_0} = 0.45 \]

\[ \lambda = \ln 2 / \frac{t}{2} = 0.693 / 5730 \text{ yrs} = 1.209 \times 10^{-4} \text{ per year} \]

\[ \ln (N/N_0) = \ln (e^{-\lambda t}) = -\lambda t \]

\[ \ln (0.45) = -0.7985 \]

\[ -0.798 / -\lambda = \text{time} \]

\[ -0.798 / -1.209 \times 10^{-4} \text{ yr}^{-1} = 6604.6 \text{ yrs} \]
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First step is to figure out ....How much K is there in the body....
70kg body 0.27% Pottassium and of that potassium 0.012% is Potassium 40...
Amount of potassium-40 is 70kg x 10^3 g/kg x 0.0027 x 0.00012= 2.33x10^-2 g

How many atoms is that? 2.33x10^-2 g /(40g/mole) x 6.023x10^23 atoms/mole=3.41x10^20 atoms

Second step is to figure out ....what is the activity of these number of atoms...
Activity = \( \lambda N \)
\( \lambda = \ln 2/t_{1/2} = 0.693/1.28x10^9 \text{ yrs} \times 3.14x10^7 \text{ s/yr} = 1.724x10^{-17} \text{ s}^{-1} \)
Activity = 1.724x10^{-17} s^{-1} x 3.41x10^20 atoms = 5879 decays/s

Third step is to calculate DOSE which is the amount of energy deposited in mass...... E/kg
Dose = (Activity x Energy of decay x time )/ mass of the body= 
= [5879 decays/s x 0.5 MeV/decay x 72 yrs x 3.24x10^7 s/yr]/ mass of body (70kg)=
= 9.50 x 10^{10} \text{ MeV/Kg}

Unit of Dose is Gray....

Exposure = Dose x Quality Factor
12. Extra Credit: 15 pts.

We are exposed to natural background radiation in the order of 2.4 mSv/year. The radiation levels around Japan on March 21, 2011 are shown in the figure below in units of microSieverts/hour. If a 20 yrs. old student refused to evacuate and stayed in the Fukushima area with a 7.47 µSv/hr exposure rate. How much does she increase the chances of getting cancer from this exposure? The rate has already dropped to 4 µSv/hr as of Nov. 2, 2011.

The US Nuclear Regulation Commission (NRC) estimates the risk of death associated with exposure to 30 µSv as one in a million – the same as spending two days exposed to the air pollution in New York.

Average lifetime is 75

2.4 mSv/yr x 75 yrs = 180 mSv of exposure

Normal risk of death associated with exposure of 30uSv is 1 in a million

180 mSv/30 uSv = 6000 chances in 1 million

For 20 yr old person 2.4mSv/yr x 20 yrs = 48 mSv

48mSv/30uSv = 1600 chances in 1 million

Fukushima (Exposure is 7.47 mSv/hr to 4 mSv/hr from March 21, 2011 to Nov 2…….)

Figure out how many days. 225 days (225 days x 24 hrs/day = 5400 hrs)

Can take an average of the exposure…about 5.75 mSv per hour...

Total extra exposure 5400 hrs x 5.75 mSv/hr = 31050 uSv

Normal risk of death associated with exposure of 30uSv is 1 in a million

31050uSv/30uSv = 1035 in a million…..almost a factor of 1

Chances of increased cancer less than 20 yrs of natural background (1600)
And less than a whole lifetime of natural background (6000) a factor of 0.17....

Smoking increases chances from cancer 23 times for men and 13 times for women