Note: You can use this assignment to replace the grade on any one previous assignment, including any assignment that you missed

1. If you have 4.5 µg of ^{185}Pb what is its activity? Here are the the steps you need to take.
   a. Look up the half life of ^{185}Pb, in seconds. 4.1 seconds
   b. From the atomic mass calculate how many nuclei you have in 4.5 µg.
      i. Mass of one nucleus = 185 *1.66 x 10^{-27} = 3.07 x 10^{-25} kg = 3.07 x 10^{-22} g
      ii. Number of nuclei = 4.5.x 10^{-6} / 3.07 x 10^{-22} = 1.46 x 10^{16}
   c. Calculate the activity, that is the number of α particles emitted per second.
      i. Decay constant (k) = ln2/$T_{½}$ = 0.169
      ii. Activity = 0.169 * 1.46 x 10^{16} = 2.48 x 10^{15} α particles per second
   d. If you stand 3 m (about 10 feet) from the source, what will be the dose rate that you receive? Zero. α particles won't travel more than a few centimeters in air.

2. What does the acronym SALT mean Strategic Arms Limitation Treaty
   a. What were the dates of SALT I and SALT II?
   b. What was the goal of the two agreements with the Soviets?
   c. What were their ultimate fates?
      i. SALT I
         . 1969
         . froze the number of strategic ballistic missile launchers at existing levels
         . provided for the addition of new submarine-launched ballistic missile (SLBM) launchers only after the same number of older intercontinental ballistic missile (ICBM) and SLBM launchers had been dismantled.
      ii. SALT II
         . 1979
         . controversial experiment of negotiations between Jimmy Carter and Leonid Brezhnev from 1977 to 1979
         . sought to curtail the manufacture of strategic nuclear weapons. It was a continuation of the progress made during the SALT I talks, led by representatives from both countries.
         . SALT II was the first nuclear arms treaty which assumed real reductions in strategic forces to 2,250 of all categories of delivery vehicles on both sides
         . not ratified in response to the Soviet invasion of Afghanistan

3. What does the acronym START mean STrategic Arms Reduction Treaty
   a. What were the dates of START I, START II, and START III?
   b. What was the goal of these agreements with the Soviets?
   c. What were their ultimate fates?
      i. START I
         . signed on 31 July 1991 and entered into force on 5 December 1994

Maximum deployment of 6,000 nuclear warheads
.   Maximum of 1,600 ICBMs, submarine-launched ballistic missiles, and bombers.
.   resulted in the removal of about 80 percent of all strategic nuclear weapons then in existence.
.   expired 5 December 2009.
   ii. START II
.   Treaty signed 1993
.   banned the use of MIRV's (multiple independently targetable reentry vehicles)
.   (2002) Russia withdrew from the treaty in response to U.S. withdrawal from the ABM Treaty.
   iii. START III
.   Proposed but never signed
.   intended to limit number of warheads on ICBM's

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4. From Dr Strangelove: Having launched the attack on the Soviet Union, the only way to recall the bombers is to send the secret 3-letter code (OPE). Unfortunately only Ripper knows what it is, and he's not telling. The suggestion is made that they try all of the possible combinations until they get the right one, but the idea is discarded because of the impossibility of sending each combination in turn in the short time available.

   a. The code comprised How many possible combinations would they have to try to find the right one? (Note: The quoted number is a slight approximation to the correct one.) $26^5 =$ 17,576

   b. If you assume they try the combinations in order, that is starting with AAA and progressively increasing the first letter, the second, and finally the third how many combinations will they go through before hitting on the right one?

   The right combination was OPE. Before hitting the right combination they would need to go through the following:

1st letter	2nd letter	3rd letter	Number of tries	
Any, A to Z	Any, A to Z	A, B, C ,D	26*26*4 =	2704
Any, A to Z	Any, A to O	E	26*15*1 =	390
Any, A to O	P	E	15*1*1 =	15
			Total =	3109

5. As a result of a hypothetical accident the inhabitants of the surrounding area receive an extra long term dose of radiation:

   a. 50,000 people receive an extra 25 mrem per year 0.04% * 50,000 * 0.025 = 0.5
   b. 80,000 people receive an extra 15 mrem per year 0.04% * 80,000 * 0.015 = 0.48
   c. 200,000 people receive an extra 5 mrem per year 0.04% * 200,000 * 0.005 = 0.4
   d. 2,000,000 people receive an extra 1 mrem per year 0.04% * 2,000,000 * 0.001 = 0.8

   How many extra deaths per year would expect as a result of this accident?

   0.5 + 0.48 +0.4 + 0.8 = 2.18. You would expect there to be 2 deaths resulting from this accident.

6. In an assignment last semester we looked at the total amount of nuclear waste generated by nuclear power plants, and envisioned that as corresponding to a pile covering a football field about 1 m deep.
   a. Look up the amount of high level nuclear waste resulting from military applications. About 104 million tons
   b. If this waste is also piled 1 m high, how many football fields would it cover? This is about 104,000,000/75,000 = 1500 times more waste from nuclear power plants. Since the waste from power plants covered one football fields to this depth, the military waste would cover 1500 football fields

7. A sample contains ⅓ ^{137}Cs and ⅔ ^{60}Co.
   a. How long will it take for the activity of the Cs to drop to ¼ of its initial value? Two half lives (30 years for ^{137}Cs), or 60 years
   b. How long will it take for the activity of the Co to drop to ¼ of its initial value? Two half lives (5.26 years for ^{60}Co), or 10.52 years
   c. How long will it take for the activity of the whole sample to drop to ¼ of its initial value? (Note: it might be easier to solve this question graphically. You can easily draw the relevant graph using a spreadsheet program such as Excel.)

      i. Since we have a mixture we would expect the answer to be between the two answers above, that is somewhere between 10.5 and 60 years.
      ii. If you make the plot, then from it you can get the right answer, about 20 years.
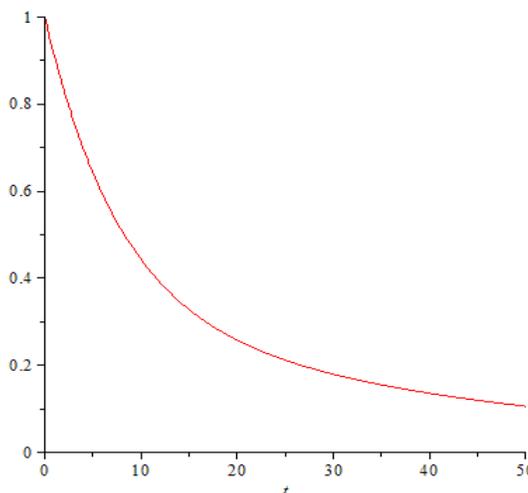
8. A PET scan (positron emission tomography) works by injecting a molecule containing a β^+ emitter, which emits a positron rather than a β^- emitter which emits an electron. The following are all isotopes which can be used. For each one what is the daughter isotope?
   a. ^{11}C ^{11}B
   b. ^{13}N ^{13}C
   c. ^{15}O ^{15}N
   d. ^{18}F ^{18}O

9. Give as may reasons as you can why ionization of DNA might be inconsequential. Any five of the following:
   a. DNA recaptures an electron without suffering any damage
   b. DNA is damaged but correctly repairs itself
   c. DNA is damaged such that that one cell dies
   d. DNA is damaged, but in a section between the genes
   e. DNA is damaged but although a codon is changed it still puts the correct amaino acid in a protein chain
   f. DNA is damaged, but the mutation has little effect (such as change of eye colour)

10. Which do you think is the more likely, the scenario of *On the Beach*, or that of *Alas Babylon*? Explain your reasoning.