PCS406: Assignment #2
(Winter 2018)

Student Name:
Student ID#:

Mark:

Due Date: ***March 1, 2018 at 17h.*** Submit a single sided hardcopy to our Teaching Assistant, Jae Lee's mailbox in KHS 331A. Late submissions will be accepted with a late penalty of -15% of the total attainable grade per day. Assignments which are over 72 hours late, without any valid reason, will not be graded and a grade of zero (0) will be assigned. Late assignments must be date/time stamped by the Department of Physics (KHE 332A).

Assignment preparation: All assignments must be typeset using a word processor or neatly hand-written for easy reading. Your assignment must have your full name and student number as shown in RAMSS.

Some technical details: *Do not work in groups or share your solutions with your colleagues.*
Solve problems in the fashion in the Cember and Johnson textbook, where each step is described in detail and the units are carried within the problem. All mathematical notations must be that used as in the textbook or you must clearly define any symbols. SHOW ALL STEPS TO YOUR SOLUTIONS.

You are a Health Physicists at a University and you knew it was going to be a bad day when on the way to work, a TTC bus splashed rain water on you after driving over the biggest pot hole on Young Street. You decide to go into the laboratory to change your wet clothes and have a cup of coffee to settle the nerves. Feeling better, you go into the next laboratory to visit your friend and discover that the interlock system on the ^{60}Co irradiation source wasn't working and you had just walked through a radiation field. Feeling shaken again, you quickly retreat to your laboratory to do a final experiment with ^{131}I. Your horrible day continues as you accidentally add HNO_3 instead of a reducing agent to the iodide solution, and as a result, you spill the solution and create some ^{131}I vapor. Fortunately, an iodine monitor was operational during this episode. You decide to retreat to your office and calculate your personal dose. Unfortunately, you have loaned your ICRP Annals to a student, and so you have to do the calculations from first principles.

You remember that ^{60}Co decays with the emission of 1.17 and 1.33 MeV gamma-rays, each of 100% abundance. And that ^{131}I emits both gamma and beta radiation and that the average energy of each ^{131}I beta particle is:

Energy (MeV/transition)	Yield, *f*
0.0701	0.016
0.0955	0.069
0.1428	0.005
0.1917	0.904
0.2856	0.006

(A) For ^{60}Co

You walked toward the ^{60}Co source at a rate of 1.5 m/s, at a distance of 2 m you stopped to look into the ^{60}Co (20 Ci) source for 20 seconds realizing that the interlock system is not operating and that the source is not in its shield, and you run out of the laboratory at a rate of 5 m/s.

1) Calculate your total absorbed dose from vising your friend's laboratory and report your answer in SI units.
2) Calculate the absorbed dose rate to the cortical bone, skeletal muscle tissue, adipose tissue, lung tissue and water from this incident. Mass energy absorption coefficients (μ_{en}/ρ) can be found at the NIST database \Photon Cross Section Database: Material Specific". The link is provided at the end of this assignment.
3) Calculate your effective dose from this exposure to ^{60}Co.
4) Based on actual measurements two days later, you determine that the source was 18.5 Ci. If the source was retracted in the shielding made of 10 cm lead and you passed 2 meters in front of the shielded ^{60}Co source and you estimate your exposure time was 20 seconds, as described in the incident, calculate the change in your equivalent dose compared to the incident scenario.

(B) For ^{131}I

1) Luckily you had an air sampler in the breathing zone when your disaster occurred. Air is pumped at a rate of 0.02 m^3 min^{-1} through a charcoal filter with an iodine collection efficiency of 100%. Both the sampling time and inhalation time were 10 minutes and the filter was counted immediately after collection. The room volume is 72 m^3. If the corrected activity on the filter was 8.2 x 10^6 disintegration per minute (dpm), what was your skin dose being immersed in this environment?
[Note for now we will neglect the internal dose due to the inhalation of radioactive ^{131}I.]
2) Due to the spill of the ^{131}I (300μCi) solution, a circular area of 0.5 m in diameter was contaminated on the bench. What is the maximum equivalent dose rate at a distance of 30 cm from the contaminated area?
3) You have to clean this spill as soon as possible. What is the equivalent dose rate if a 50 cm long tongs are used during the cleaning of this spill, which can take up to 5 min to complete?

(C) For the incident itself:

(1) What value would you quote for your effective dose of this day at work?
(2) How does your effective dose from all these incidents compares to the Canadian annual radiation dose to an occupational exposed person such as you? Do you need to stop or modify your work habits?
(3) If the risk factor for mortality is 1.25 x 10^2 per Sv, what is your risk from this incident?
(4) The previous incident has left you shaken to such an extent that you start smoking cigarettes. If the risk is 2 x 10^{-1} per cigarette, how long do you have to smoke a package of 20 cigarettes a day to equal the risk from your blundering in the laboratory?
(5) You decide to quit smoking. To help, you take a vacation to Rockies, where you will climb a few mountains and do some canoeing. During you vacation, you drive your car for a total of 100 h, you canoe for another 100 h and climb for an additional 50 h. If these activates have the risk factors of 0.95 x 10^{-6} h^{-1}, 1 x 10^{-5} h^{-1} and 4 x 10^{-5} h^{-1}, respectively, what effective dose corresponds to the same risk of mortality as your vacation?

Useful Databases

National Institute of Standard and Technology (NIST) XCOM: Photon Cross Section Database http://www.nist.gov/pml/data/xcom/index.cfm

National Institute of Standard and Technology (NIST) XCOM: Photon Cross Section Database: Material Specific http://physics.nist.gov/PhysRefData/XrayMassCoef/tab4.html

National Institute of Standard and Technology (NIST) Stopping-Power and Range Tables for Electrons, Protons, and Helium Ions (ESTAR, PSTAR, ASTAR Databases) http://www.nist.gov/pml/data/star/index.cfm

Table of Radioisotopes 1 http://ie.lbl.gov/toi/perchart.htm

Table of Radioisotopes 2 http://nucleardata.nuclear.lu.se/nucleardata/toi/perchart.htm

Radioactive Decay Data http://www.nndc.bnl.gov/ensdf/dec_form.jsp

Integration Tables http://integral-table.com/

Open Source Software

OpenSource Office Suite at OpenO_ce.org http://www.openoffice.org/ 20