RADIATION SAFETY COURSE
STUDY GUIDE

Calculations and Conversions: - Each student should be able to perform the following calculations and/or conversions by using methods described in the class:

1. Calculate the radioactive decay of different isotopes,
2. Using detection efficiencies convert cpm to dpm,
3. Convert μCi to dpm and to dps (Bq),
4. Convert roentgens to rads, rads to rems, rads to grays and rems to sieverts,
5. Inverse square law (for determining exposure rates),
6. Calculate exposure rates using the specific gamma ray constant,
7. Calculate shielding requirements for gamma emitters, and
8. Determine beta shielding requirements using a graph.

Numbers to memorize:

1.	5 rem	2.	1/3 E_{MAX}	3.	4 in 10^4
4.	5 mrem/h	5.	300 - 400 rads	6.	300 mrem/y
7.	2.22 x 10^6 dpm	8.	3.7 x 10^4 dps	9.	37 MBq

Number prefixes:

micro (μ) = 10^{-6}	kilo (k) = 10^3
milli (m) = 10^{-3}	mega (M) = 10^6
centi (c) = 10^{-2}	giga (G) = 10^9
	tera (T) = 10^{12}

Units to memorize	*Conventional Units*	*SI Units*
Activity (quantity):	curie (Ci)	bequerel (Bq)
Exposure:	roentgen (R)	no unit
Absorbed dose:	rad	gray (Gy)
Dose equivalent:	rem	sievert (Sv)

Shielding and Inverse square problem

For the isotope ^{59}Fe with an activity of 5 mCi, what is the exposure rate at 10cm?

From the Table of Radioisotopes

Specific Gamma Ray Constant = Γ = 6 R / hr @ 1 cm per mCi

So for 5 mCi, I_o = 6 R / (hr mCi) x 5 mCi = 30 R / hr = 30,000 mR / hr @ 1 cm

At 10 cm the rate will be $(10 \text{ cm} / 1 \text{ cm})^2$ = 100 times less

I = (30,000 mR / hr) / 100 = 300 mR / hr

What will the exposure rate become if 1 cm of lead is used as a shield?

From the Table of Radioisotopes

Tenth Value Layer = TVL = 33.6 mm Pb = 3.36 cm Pb

Method 1:

$I = I_o (1 / 10)^n$, where I_o = 300 mR / hr n = #TVL's = 1 cm / 3.36 cm = 0.30

$I = 300 \text{ mR / hr } (1 / 10)^{0.3} = 300 \times 0.50 = 150 \text{ mR / hr}$

Method 2:

$I = I_o e^{-2.3 X / TVL}$, where X = thickness of shield = 1 cm

$I = 300 \text{ mR / hr} \times e^{-(2.3 \times 1 / 3.36)} = 300 \times 0.50 = 150 \text{ mR / hr}$

Method 3:

Use of nomogram on page A10 of the manual

Number of TVL's = 1 cm / 3.36 cm = 0.30

The nomogram indicates that 50% of the exposure remains after passage of radiation through 0.30 TVL's

I = 0.50 x 300 mR / hr = 150 mR / hr

RADIATION SAFETY COURSE
UNITS AND DOSES

1. PREFIXES: Complete the following conversions:

   (a) 6¢ = _____ $ = _____ m$ (b) 100 μCi = _____ Ci

   (c) 3.3 Ci = _____ mCi (d) 2×10^6 μCi = _____ Ci

   (e) 50 mrem = _____ rem (f) 42 R / h = _____ mR/h

   (g) 10^6 dpm = _____ μCi (h) 4 μCi = _____ dis / sec

2. UNITS: Indicate the correct units:

   (a) MPD for eyes of the radiation worker is 15 _____ mrem / y
   _____ rem / y
   _____ R / y

   (b) Effective whole body dose equivalent from naturally occurring radiation sources is 300
   _____ μCi / y
   _____ rem / y
   _____ mrem / y

   (c) The absorbed dose rate from an activity of 1 μci per square centimeter of ^{32}P deposited on the skin is 9 _____ rads / h
   _____ rads / cm^2
   _____ μCi / cm^2

3. RADIATION EXPOSURES: Absorbed Doses and Dose Equivalents

   Select answers from :
   0 mR, 20 mR, 5 R
   0 mrads, 100 mrads, 340 rads
   0 mrem, 5 mrem, 1250 mrem, 1 rem, 1.25 rem,
   20 rem, 50 rem

   (a) Max. permissible dose equivalent (gonads), radiation worker: _____ / yr

   (b) "Radiation Area" = whole body dose equivalent ≥ _____ / h

   (c) Whole body dose equivalents which gives cancer mortality risk of 4 in 10,000: _____

   (d) LD_{50} absorbed dose (with minimal treatment): _____

   (e) Exposure rate at 1 cm from 10 mCi of ^{86}Rb: _____

   (f) Dose equivalent from 1 rad of alpha radiation: _____

   (g) Absorbed dose threshold for induction of genetic effects: _____

4. What is the total dose equivalent which should be recorded in a person's dosimetry records if he/she has received the following individual doses? (Give answer in conventional and SI units.)

5. SI Unit Conversions

    a. 1 mGy to rads

    b. 4 μCi to Bq

    3. 74 kBq to μCi

    4. 5 mrads/h to mGy/h

    5. 1.25 rem to mrem, mSv, and Sv

    6. 4 mCi to Mbq

    7. 10 rads to 10 cGy

RADIATION SAFETY COURSE
PROBLEM SET

1. How much ^{125}I activity remains 200 days after calibration if the initial activity is 10 mCi?

2. A certain procedure which involves the use of ^{198}Au is performed over a 4 hour period at a working distance of 20 cm. If the exposure rate from the ^{198}Au is 10 mR/hr, the total integrated exposure to the radiation worker would be 40mR. Assume that it is possible to change the working parameters of the procedure in order to reduce the exposure. What would the exposure be if:

    8. The TIME were reduced to 2 hours? _____ mR

    9. The DISTANCE were increased to 60 cm? _____ mR

    10. If 1 cm of lead SHIELDING were used, what would the exposure be? (TVL=10 mm Pb) _____ mR

    11. If all three of the above were done? _____ mR

3. What is the dose rate through the protective layer of skin from a 2 μCi / cm^2 deposition of ^{32}P? (See Rules of Thumb for beta particles.)

4. What is the (gamma) exposure rate at 20 cm from a 3 mCi vial of ^{131}I?

5. If the exposure rate from some ^{51}Cr with no shielding is 20 mR / hr, what is the exposure rate reduced to if 2 mm Pb is used for shielding?

6. What is the meaning of the following terms?

    1. LD_{50}

    2. Genetic effects of radiation

7. A person who has an annual intake of radioisotope equal to the ALI (Annual Limit on Intake) will receive an absorbed dose equal to the MPD (maximum permissible dose). What fraction of the MPD is received if a person has an intake of 1 mCi for the following isotopes?

Isotope	ALI	Fraction or multiple of MPD
^{3}H	_____	_____
^{125}I	_____	_____
^{45}Ca	800 µCi	1.25
^{14}C	_____	_____
^{99m}Tc	80,000 µCi	0.01

On the basis of the above numbers, which isotope is most toxic:_____; least toxic:_____

8. All of the following biological effects may result from exposure to radiation. Most, however, require large doses of radiation (there is a threshold below which the effect does not occur). Indicate those for which there is no known threshold, i.e., may have a possibility of occurring even with low doses.

_____ Mutations	_____ nausea	_____ leukemia
_____ sterility	_____ dermal necrosis	_____ cancer
_____ cataracts	_____ erythema	_____ epilation
_____ genetic effects	_____ acute radiation syndrome	

9. The radiological half-life of ^{125}I is 60 days. The biological half-life is 138 days (for soluble forms). What is the effective half-life?

10. Cancer induction by ionizing radiation:

What is the threshold for cancer induction?

Answer: _____ rads

What is the latent period (for solid cancers)?

Answer: _____ years

What is the risk factor?

Answer: _____ fatal cancers / rem whole body dose

What is the risk of having a fetal cancer induced by a whole body radiation dose of 5 rads?

Answer: 1 chance in _____

11. What is the major risk to the embryo of fetus during the:

first 8 days of pregnancy _____
remainder of the 1st trimester _____
last 6 or 7 months of pregnancy _____

(a) birth defects
(b) fetal death
(c) death of embryo
(d) increased childhood risk of cancer