Radiation Safety Course

Review Session

Units & Doses

1.Prefixes

a. 6 cents x $\frac{1\ \$}{100\ \text{cents}}$ = 0.06 $

0.06 $ x $\frac{1{,}000\ \text{m\$}}{1\$}$ = 60 m$

b. 100 μCi x $\frac{1\ \text{Ci}}{1 \times 10^{6}\ \mu\text{Ci}}$ = 1×10^{-4} Ci

c. 3.3 Ci x $\frac{1{,}000\ \text{mCi}}{1\ \text{Ci}}$ = 3,300 mCi

d. 2 x 10^{6} μCi x $\frac{1\ \text{Ci}}{1 \times 10^{6}\ \mu\text{Ci}}$ = 2 Ci

1. Prefixes, continued

e. 50 mrem x $\frac{1\ \text{rem}}{1{,}000\ \text{mrem}}$ = 0.05 rem

f. 42 R/h x $\frac{1{,}000\ \text{mR/h}}{1\ \text{R/h}}$ = 42,000 mR/h

g. 10^{6} dpm x $\frac{1\mu\text{Ci}}{2.22 \times 10^{6}\ \text{dpm}}$ = 0.45 μCi

h. 4 μCi x $\frac{3.7 \times 10^{4}\ \text{dps}}{1\ \mu\text{Ci}}$ = 1.48×10^{5} dps

2. Units: Indicate the correct units:

(a) MPD for eyes of a radiation worker is 15

____ mrem/y _X_ rem/y ____ R/y

(b) Effective whole body dose equivalent from naturally occuring radiation sources is 300

____ μCi/y ____ rem/y _X_ mrem/y

(c) The absorbed dose rate from an activity of 1 μCi per cm^2 of ^{32}P deposited on the skin is 9

_X_ rads/h ____rads/cm^2 ____μCi/cm^2

3. Radiation Exposures: Absorbed Doses & Dose Equivalents

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

a. Maximum permissible dose equivalent (gonads) radiation worker: 50 rem/y, 20 rem/year -implied

b. "Radiation Area" = whole body dose equivalent ≥ 5 mrem/hour.

c. Whole body dose equivalents which gives cancer mortality risk of 4 in 10,000: 1 rem

3. Radiation exposures, cont.

d. LD_{50} absorbed dose (with minimal treatment): 340 rads

e. Exposure rate at 1 cm from 10 mCi of ^{86}Rb: 5 R/hour.

f. Dose equivalent from 1 rad of alpha radiation: 20 rem.

g. Absorbed dose threshold for induction of genetic effects: 0 mrads.

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.)

x-rays:	210 mrads	x	1	=	210 mrem
alpha rays:	60 mrads	x	20	=	1200 mrem
beta rays:	150 mrads	x	1	=	150 mrem
gamma rays:	30 mrads	x	1	=	30 mrem
thermal neutrons:	10 mrads	x	2.3	=	23 mrem
TOTAL:					1,613 mrem

$$1{,}613 \text{ mrem} \times \frac{1 \text{ rem}}{1{,}000 \text{ mrem}} = 1.613 \text{ rem}$$

$$1.613 \text{ rem} \times \frac{10 \text{ mSv}}{1 \text{ rem}} = 16.13 \text{ mSv}$$

5. SI Units:

a. $1 \text{ mGy} \times \frac{100 \text{ mrads}}{1 \text{ mGy}} = 100 \text{ mrads}$

b. $4\ \mu\text{Ci} \times \frac{3.7 \times 10^4 \text{ Bq}}{1\ \mu\text{Ci}} = 1.48 \times 10^5 \text{ Bq}$

c. $74 \text{ kBq} \times \frac{1{,}000 \text{ Bq}}{1 \text{ kBq}} \times \frac{1\ \mu\text{Ci}}{3.7 \times 10^4 \text{ Bq}} = 2\ \mu\text{Ci}$

d. $5 \text{ mrads/h} \times \frac{0.01 \text{ mGy/h}}{1 \text{ mrad/h}} = 0.05 \text{ mGy/h}$

5. SI Units, cont.

e. $1.25 \text{ rem} \times \frac{1{,}000 \text{ mrem}}{1 \text{ rem}} = 1{,}250 \text{ mrem}$

$1.25 \text{ rem} \times \frac{10 \text{ mSv}}{1 \text{ rem}} = 12.5 \text{ mSv}$

$1.25 \text{ rem} \times \frac{0.01 \text{ Sv}}{1 \text{ rem}} = 0.0125 \text{ Sv}$

f. $5 \text{ mCi} \times \frac{37 \text{ Mbq}}{1 \text{ mCi}} = 185 \text{ Mbq}$

g. $10 \text{ rads} \times \frac{1 \text{ cGy}}{1 \text{ rad}} = 10 \text{ cGy}$

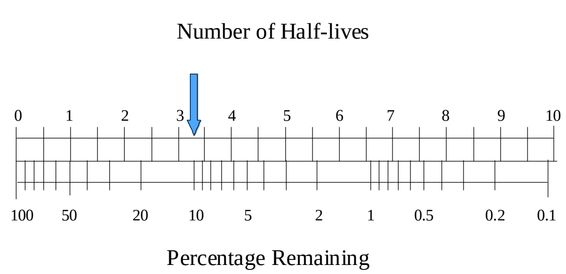
Problem Set: Basics of Radiation Safety

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

A. Nomogram method
Half-life of ^{125}I = 60 days
# of half-lives = 200 days/60 days = 3.33

From nomogram (p. A11), 10% of the initial activity remains, so:
A = 0.1 x 10 mCi = 1 mCi

Decay Nomogram



1. cont.

B. Formula method
Half-life of ^{125}I = 60 days

$$A = A_0 e^{(-0.693)(t/T1/2)} = 10e^{(-0.693)(200/60)}$$
$$= 10^{-2.31} = 10 \times 0.099 = 0.99 \text{ mCi}$$

(or)

$$A = A_0(1/2)^N = 10(1/2)^{(200/60)} = 10(1/2)^{3.33}$$
$$= 10 \times 0.099 = 0.99 \text{ mCi}$$

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 40 mR. 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

a. The **time** were reduced to 2 hours? 20 mR
(Time and therefore dose are cut in half.)

b. The **distance** were increased to 60 cm?
$I_2 = I_1(d_1/d_2)^2 \quad I_2 = 40\text{ mR}(20/60)^2 = \underline{4.4\text{ mR}}$

c. If 1 cm of lead **shielding** were used? (TVL = 10 mm Pb)
$I = I_0 e^{(-2.3x/TVL)} = 40\text{ mR}e^{(-2.3)10mm/10mm)} = \underline{4\text{ mR}}$

d. If **all three of the above** were done?
40 mR x 20/40 x 4.4/40 x 4/40 = 0.22 mR

3. What is the dose rate through the protective layer of skin from a 2 µCi deposition of ^{32}P? (See 'Rules of Thumb for Beta Particles' on page A10.)

$$D(\text{rad/h}) = 9B = 9 \times \frac{2\ \mu Ci}{cm^2} = \underline{18\text{ rads/h}}$$

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

Γ = 2.1 R/h @ 1 cm per mCi (From Table)

The dose rate for 3 mCi:
3 x 2.1 = 6.3 R/h @ 1 cm

Using the inverse square law (page A11):

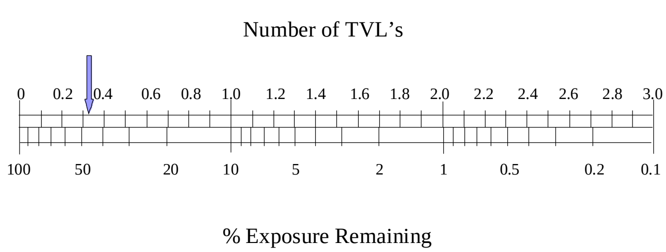
$I_2 = I_1(d_1/d_2)^2 = 6.3(1/20)^2$
$= 6.3(1/400) = 0.0158\text{ R/h} = \underline{15.8\text{ mR/h}}$

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 of Pb is used for shielding? (The TVL is 6.3 mm of Pb.)

A. Nomogram Method
\# of TVL's = 2/6.3 = 0.32
From the nomogram on p. A10, 48% is remaining.
I = 20 R/h x 0.48 = 9.6 mR/h

B. Formula Method
$I = I_0 e^{(-2.3x/TVL)}$
$= (20\text{ mR/h})e^{(-2.3)(2/6.3)} = 20(0.482) = \underline{9.6\text{ mR/h}}$
(or)
$I = I_0(1/10)^n$, where n = # of TVL's
$= (20\text{ mR/h})(1/10)^{0.32} = (20\text{ mR/h})(0.48)$
$= \underline{9.6\text{ mR/h}}$

TVL Nomogram



6. What is the meaning of the following terms?

a. LD_{50}

50% of the exposed population is expected to die within 60 days.

b. Genetic effects of radiation

Effects passed on to offspring.

7. A person who has an annual intake of a 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 (µCi)	Fraction or multiple of MPD
^{3}H	80,000	0.013
^{125}I	40	25
^{45}Ca	800	1.25
^{14}C	2,000	0.5
^{99m}Tc	80,000	0.013

On the basis of the above numbers, which isotopes most toxic? **^{125}I ,** which is least toxic? **^{3}H, ^{99m}Tc**

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, ie., may have a possibility of occurring even with low doses.

X mutations　_ nausea　**X** leukemia

_ sterility　_ dermal necrosis　**X** cancer

_ erythema　_ acute radiation syndrome

X genetic effects　_ epilation

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?

$$T_{eff} = (T_{1/2}T_b)/(T_{1/2} + T_b)$$

$$= (60)(138)/(60 + 138) = \underline{41.8 \text{ days}}$$

10. Cancer induction by ionizing radiation(p. A18)

What is the threshold for cancer induction? 0 rads

What is the latent period for solid cancers? 10 to 35 years

What is the risk factor? 4/10,000 fatal cancers/rem of whole body dose (0.0004)

What is the risk of having a fatal cancer induced by a whole body radiation dose of 5 rem? 1 chance in 500

$$5 \text{ rem} \times \frac{4}{10{,}000} = \frac{20}{10{,}000} = \frac{1}{500}$$

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

first 8 days of pregnancy C
remainder of the first trimester A
last 6 or 7 months of pregnancy D

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