$\frac{3}{4}\ \frac{2}{4}\ \frac{2}{4}$

$\cdot 64$

$8\ \boxed{2^7 = 128}$

Homework assignment RONC601B
Lecture 2 X-ray Tubes/X-ray beams
Due by January 25th 2012
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1. Three tenth-value layers (TVLs) will have approximately the same protective effect as______ half-value layers (HVLs)
   a. 5
   b. 10
   c. 15
   d. 20
   e. 25

$\frac{I'}{I}\ \frac{1}{10}$ answer $\frac{1}{10^3} = \frac{1}{2^n}$

$I = \frac{1}{2}I' = \frac{1}{2}\frac{1}{2}I'' = \frac{1}{2}\frac{1}{2}\frac{1}{2}I''' = \frac{1}{2}\frac{1}{2}\frac{1}{2}\frac{1}{2}I$

$\frac{1}{2}$ $\frac{1}{2}I_0$ $\frac{1}{4}I_0$

$2^n = 2^3 \times 5^3$

$2^{n-3} = 5^3 \Rightarrow$ $n-3=7$ $\boxed{n=10}$

2. Broad beams are not used when measuring half-value layers because:
   a. The beam must be smaller than the detector
   b. Scattered x-rays may reach the detector giving false reading
   c. The average beam energy would be increased
   d. All of the above
   e. None of the above

3. Tungsten has the following binding energies: K=69 keV, L=12keV, M=2keV. A 100 keV electron strikes a tungsten target can cause emission of a characteristic x-rays, including which three of the following energies (in keV):
   a. 100, 69, 31
   b. 98, 88, 31
   c. 95, 63, 15
   d. 57, 67, 10

$100 - 69$

$69-12 = 57$
$69-2 = 67$
$12-2 = 10$

67
57
10

4. If the filtration of an x-ray beam is increased, the resulting beam will have:
   a. A lower dose rate and a grater HVL
   b. A higher dose rate and a higher effective energy
   c. A lower dose rate, but the same HVL
   d. The same dose rate, but lower HVL
   e. The same dose rate, but higher HVL

5. The fraction of photons absorbed after passing trough n half-value layers of an absorber, which has a linear absorption coefficient of μ will be:

$I = I_0 e^{-\mu x}$

passed fraction: $e^{-n\frac{\ln 2}{\mu}\mu}$

absorbed = $1 - e^{-\ln(2)\times n}$

$\frac{I}{I_0} = \frac{1}{2} = e^{-\mu x}$

$-\ln 2 = -\mu x$

$x = \frac{\ln 2}{\mu}$

   a. $e^{-n\mu}$
   b. $e^{+n\mu}$
   c. $1-e^{-n\mu}$
   d. $e^{-\ln(2).n/\mu}$
   e. $1-e^{-\ln(2).n}$

$e^{-\mu\, n\frac{\ln 2}{\mu}}$

6. A monoenergetic photon beam which linear attenuation coefficient is 0.0693 cm^{-1} travels 10 cm of a medium. Find the fraction of the beam that is transmitted trough this medium. $\frac{1}{2}$

$\frac{I}{I_0} = \cancel{I_0}\, e^{-\frac{0.0693 \times 10}{\ln(2)}}$ $\quad e^{-\ln 2}$ $\quad \frac{I}{I_0} = \frac{1}{2}$

7. If the linear attenuation coefficient is 0.05 cm^{-1} , find the HVL considering a beam of a single energy: $\Rightarrow \frac{\ln 2}{0.05} = 13.8629\ cm$

8. The following table describes the measured intensity as a function of aluminum filter thickness:

Filter Thickness, mm	Reading, nC
0	100
1	67
2	54.9
3	48
5	40.1
10	31
15	26.5
17	25.3
18	24.7
20	23.7

(a) $\Rightarrow 67 = 100\, e^{-\mu \times 0.1\,cm} \Rightarrow$

$I = I_0 e^{-\mu x}$

$\mu = \left(\ln \frac{67}{100}\right) / (-0.1\,cm)$

(b) $\Rightarrow \mu = 4.0048\ cm^{-1}$

(a) $\Rightarrow HVL_{theory} = \frac{\ln 2}{\mu} = 0.1731\ cm$

(a) $\Rightarrow HVL_{experiment} \simeq 2$ by intrapolation

(a) $Hvl = 2 + \left(\frac{55-50}{55-48}\right)(3-2) = 2.714$

2 mm

$- \mu \cdot 20$

$23.7 = 100\, e$

$-\frac{1}{20} \ln \frac{23.7}{100} =$

a. What is the first HVL for this beam 2 mm
b. What is the attenuation coefficient for this beam in aluminum
c. The homogeneity coefficient is defined as the first HVL divided by the second. What is the homogeneity coefficient for this beam

$1st\,Hvl + 2nd\,HVL = 17.5$

$\Rightarrow 2nd\,Hvl = 17.5 - 2.714 = 14.78$

$= \frac{1st\,HVL}{2nd\,HVL} = \frac{2.714}{14.78} = 0.183$ (c)

9. Determine the % transmission of 140 keV monoenergetic beam trough 10 cm heterogeneous layer of tissue consisiting of 3 cm soft tissue, 5 cm lung tissue and 2 cm bone (Linear attenuation coefficient is 0.12cm-1 for soft tissue, 0.21cm-1 for bone and 0.04cm-1 for lung tissue)

$\frac{I_{soft}}{I_{0\,soft}} = e^{-0.12 \times 10} = 0.3012$ $\quad \frac{I_{lung}}{I_{0\,lung}} = e^{-0.04 \times 10} = 0.6703$ $\quad \frac{I_{bone}}{I_{0\,bone}} = e^{-0.21 \times 10} = 0.1225$

considering that $I_{0\,lung} = I_{soft}$ & $I_{0\,bone} = I_{lung}$

10. If is the linear attenuation coefficient of a sheet of material of thickness x and I0 and Ix are the intensities of the incident and transmitted beams respectively, which of the following is true:

a. The HVL is the thickness x, for which Ix=I0(exp-0.693)
b. The HVL is the thickness x, for which Ix=I0/2
c. The HVL is 0.693/ μ ✓
d. All of the above
e. None of the above

$I_{final} = I_{0\,soft} \times e^{-0.12 \times 10} \times e^{-0.04 \times 10} \times e^{-0.21 \times 10} \Rightarrow \frac{I_{final}}{I_{0\,soft}} = 0.02 = \boxed{2\%}$ (9)