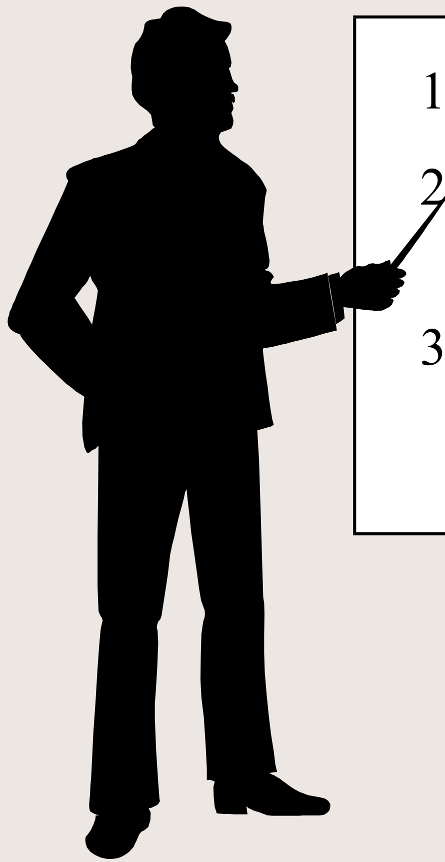
# Useful Calculations

Training Notes for URI Radiation Workers

# Three Basic Calculations



1. Decay Equation
2. Activities in Radioactive Wastes
3. Activities Using a Survey Meter

# Radioactive Decay Equation

$A = A_0 e^{-\lambda t}$

Where:

A = Current amount of radioactivity

$A_0$ = Original amount of radioactivity

e = base natural log (approximately 2.718)

$\lambda$ = the decay constant = $0.693/t_{1/2}$ (where $t_{1/2}$ = half-life)

t = the amount of time elapsed from $A_0$ to A

# Calculating λ

$A = A_0 e^{-\lambda t}$

But $A/A_o = ½$ when $t$ = half-life ($T_{1/2}$)

$½ = e^{-\lambda T1/2}$

$-0.693 = -\lambda T_{1/2}$

$\lambda = 0.693/T_{1/2}$

# Sample Calculation:

You have a vial of solution containing Phosphorus-32 with a known activity of 100 µCi on July 2.  You want to know how much activity remains on July 28, i.e., 26 days later.  The half-life of Phosphorus-32 is 14.3 days.

# Filling in the Data

We'll let A = the activity remaining on July 28.

$A_0$ is the original activity, i.e., 100 μCi on July 2.

T is the elapsed time, 26 days.

# First, we'll calculate the decay constant λ.

$\lambda = 0.693 \div 14.3$ days or $0.0485$ days$^{-1}$.

# Time Units in the Decay Equation

Be careful with the units used for the time. Seconds, minutes, hours, days and years must not be mixed in the calculation.

If the elapsed time is in days, $\lambda$ must be in $days^{-1}$ or the elapsed time must be converted to the same time units as $\lambda$.

# Then, we can calculate the remaining activity.

$$A = A_0 e^{-\lambda t}$$

$$A = 100 e^{-0.0485 \text{ x } 26}$$

$$A = 100 \text{ x } 0.283$$

The remaining activity A equals 28.3 µCi

# A Material Balance Approach for Determining the Activity in Your Radioactive Waste

1. Record the total activity used in the experiments represented in your radioactive waste. (TA)
2. Take a sample from your liquid waste storage container and count it on a Liquid Scintillation Counter.
3. Multiply the µCi/ml determined in step 1 by the number of milliliters of liquid waste in your liquid waste storage container. (If the result from step 1is in dpm/ml, divide by 2.22 x$10^6$ dpm/µCi to calculate activity per milliliter then multiply by the number of milliliters of liquid waste .) You now have an estimate of the total activity in your liquid waste container. (LW)

# A Material Balance Approach for Determining the Activity in Your Radioactive Waste (Continued)

4. If you have counted your experimental samples by Liquid Scintillation counting, sum the activities in the liquid scintillation vials. (LSV)
5. If your experiment generates gaseous wastes that have been discharged to the atmosphere, sum the estimated activities released. (GW)
6. The activity in your dry active waste (DAW) can now be determined: DAW = TA - LW – LSV - GW

# Determining Activity Using Survey Instrument Efficiency

***Suppose we detect 2,200 cpm of P-33 using a Pancake GM probe and we want to determine the P-33 activity.***

***The efficiency for P-33 with a Pancake GM probe is about 10 %.***

**Efficiency = cpm / dpm**

**dpm = cpm / Efficiency**

# Activity Calculation

**dpm = 2,200 cpm / 0.10 = 22,000 dpm = 2.2 x $10^4$ dpm**

***We know that 1 μCi = 2.22 x $10^6$ dpm.***

**2.2 x $10^4$ dpm x (1 μCi / *2.22 x $10^6$ dpm*) = 1 x $10^{-2}$ μCi or 0.01 μCi**

# Determining Activity Using a "Conversion" Factor

Suppose that your laboratory's survey meter is calibrated for P-32 and a "Conversion factor" is listed on the meter's calibration sticker; this conversion factor is the inverse of the efficiency.

If you detect 10,000 cpm of P-32 with a pancake GM probe, and have a conversion factor of 2.2.

Cpm x conversion factor = dpm 10,000 cpm x 2.2 dpm/cpm = 22,000 dpm P-32