Xiamen 2026 Radiochemistry Practical

Beta Counting

1) Detector operations

a. Plateau/high voltage set-up

Please see RISO Counter Manual guidelines. Always record the voltage. Changes in voltage may suggest issues with counting stability.

b. Detector backgrounds

In normal operations you will run a long background to determine count rate without any sample. You will note that individual detectors can vary in their background counts, with detectors located at the very front and back tending to have slightly higher background rates. This points to the importance of counting samples in the SAME channel for their initial and final counts. Normally shielding is provided by 3 to 6 inches of low background lead. Depending upon shielding and location, background will vary, so appropriate location specific background counts are needed, in various labs, at sea, etc.

c. Calibration/efficiency- notes for class activities

Goal is to generate results in activity units- Bq = counts per second/efficiency. 99Tc is a quick and easy way to monitor stability of your counter over time. However, this is NOT an appropriate standard for calibrating your detectors. It is critical to use standards of similar Beta energies given issues with self absorption (see below)

99Tc standard = known Bq (or dps) = _____, note the long half-life (no decay correction).

What is the count rate =_____ cps?

Convert from cpm to cps.

How long should you count? What do the red & green flashes denote?

What is detector background = _____ (why so low?)

Calculate the detector efficiency =_____

Calculate the uncertainty in your calculated Bq (1/square root of net counts) =_____ What other errors besides count rate should be included here?

d. external absorption- in class testing of different external absorbers

In beta counting there is no discrimination by energy of the different beta energies. Hence often samples are covered by various external absorbers to block/shield low energy betas from being counted when high energy betas are desired. This is the case for ^{234}Th measured on the Mn precipitate, as the daughters of ^{238}U decay series are mostly low energy betas, which can be blocked with a simple foil

cover, allowing detection of a much higher energy ^{234m}Pa beta exclusively (^{234m}Pa is in secular equilibrium with ^{234}Th due to its very half-life, 1.2 min, relative to ^{234}Th).

What is effect of adding Al foil? Al foil density (g/cm^2) = ____

What is count rate without foil/with foil = _____

Does this match expectations?

Need to know (how would you find out?)

Energies: beta max.

99Tc = 0.294 MeV

^{234}Th = 0.188 MeV

^{234m}Pa = 2.28 MeV

Using "Nomogram" what % beta signal would be lost from a 99Tc source if you used one layer of Al foil (4.5 mg/cm2 thickness)? _____

e. Application to ^{234}Th in seawater

^{234}Th half life = 24.1 d- what is energy of beta = _____

Review sample collection, preparation, Mn precipitation; idea of chemical yield, decay, ingrowth

What isotope are we measuring on beta counter? ^{234m}Pa- what is energy = _____

Is ^{234m}Pa in secular equilibrium?

What about other U-Th series isotopes in Mn precipitate?

What do you need to know beyond just count rate and detector efficiency to calculate ^{234}Th activity in seawater?

1. sample volume
2. decay ^{234}Th between precipitation and counting and between sampling and precipitaton
3. ingrowth from 238U between sampling and precipitation
    a. filtration can take 6-12 hours; U not carried by MnO2 but Th, Ra is carried
4. chemical yields
    a. add ^{230}Th for later analyses; ppt is not 100% efficient; use ICPMS or alpha after final count
5. Final count after 6 months- other beta emitters from Ra daughters

Enter data & review spreadsheets

What would count rate look like in 10 days? 24.1 days? 48 days? After 6 months?

Exponential decay $A = A_0 \exp(-\lambda * t)$

λ= ln2/ half life = _____

what units? (d^{-1})

^{234}Th ingrowth = $238U (1- \exp(-\lambda * t))$

How do we know 238U? = 0.0713 x salinity = dpm/L X 1/60 = Bq/L

For salinity = 35, what is 238U = _____ dpm; = _____ Bq

Notes here: