Q1 ANALYSIS OF SEDIMENTATION PATTERNS USING LEAD-210 (10 pts)

Part 1. Calculation of Tracer Activity and Relative Efficiency (2.1 pts)

1.1

Isotope	λ		
Pb-210	0.0311	y^{-1}	0.1 pt
Po-210	0.0050	d^{-1}	0.1 pt
Po-208	0.2366	y^{-1}	0.1 pt

Accept variation in the decimal places in red

1.2

Average: 0.5679 Bq/ml or 34.0718 dpm/ml — 0.3 pt
Accept 0.56~0.57
Standard Deviation: 0.0028 Bq/ml or 0.1664 dpm/ml — 0.2 pt
Accept 0.002 – 0.003

1.3 (a)

Depth range, cm	Po-208 Counts	Experimental Tracer Activity, dpm
0 – 1	1251	0.9068
29-30	1079	0.7473

0.8 pt (0.2 pt each)

Accept variation in the decimal places in red

1.3 (b)

Average relative efficiency: 0.1262 — 0.3 pt
Standard Deviation: 0.0323 — 0.2 pt
Accept variation in the decimal places in red

Part 2. Lead-210 Determination (2.3 pts)

2.1

Depth range, cm	Total Po-210 Activity, Bq/kg	Total Pb-210 Activity, Bq/kg	Error, ± Bq/kg
0 – 1	122.6525	124.4292	9.6450 ~10
29 – 30	86.4196	87.6715	7.9870 ~8

1.2 pts (0.2 pt each)

Accept variation in the decimal places in red

2.2

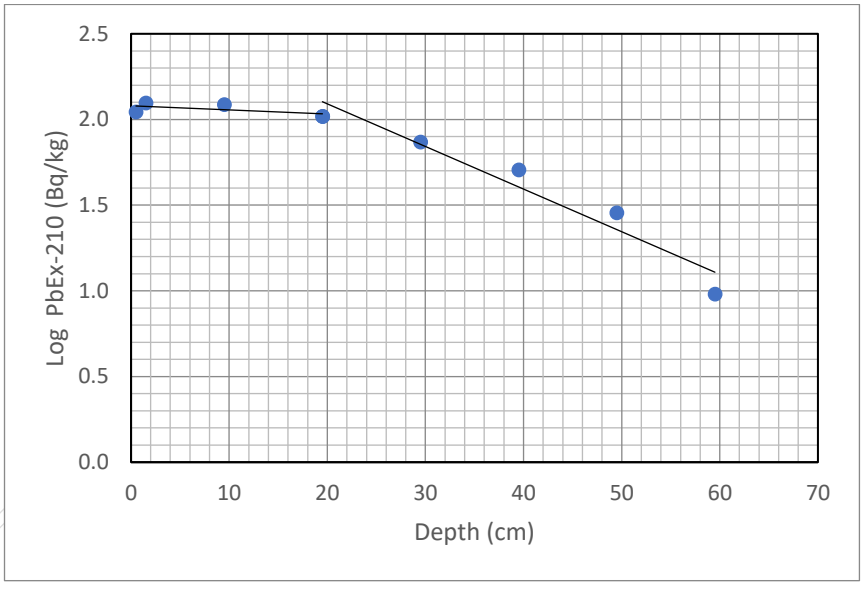
Supported Pb-210: 13.6352 Bq/kg — 0.8 pt

Standard Deviation: 4.4691 Bq/kg — 0.3 pt

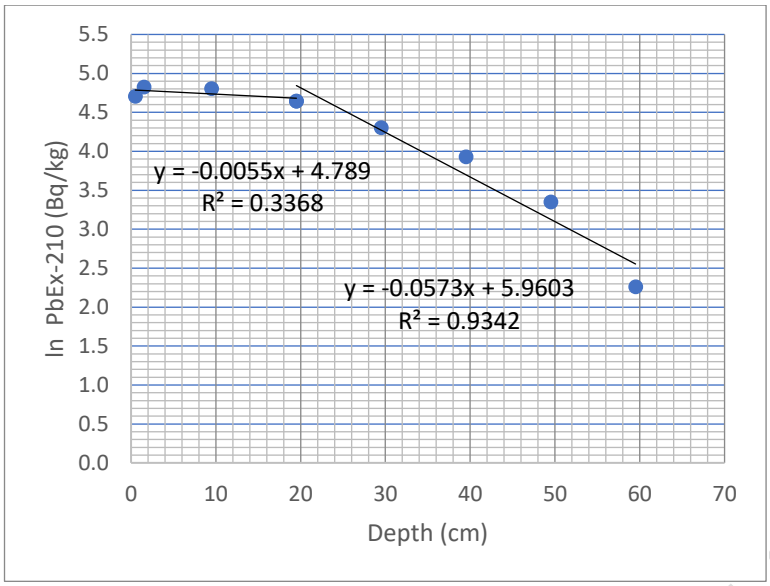
Accept variation in the decimal places in red

Part 3. Lead-210 Geochronology (4.6 pts)

3.1 (a)



1.4 pts
(Axis label = 0.1 pt each
Data points = 0.05 pt each
Fit lines = 0.4 pt each



3.1 (b)

Depth (x)	LogPbEx-210 (y)	xy	x^2
0.5	2.0445	1.0223	0.2500
1.5	2.0957	3.1436	2.2500
9.5	2.0866	19.8229	90.2500
19.5	2.0179	39.3482	380.2500
$\Sigma x = 31.0$	$\Sigma y = 8.245$	$\Sigma xy = 63.337$	$\Sigma x^2 = 473.0000$

0.7 pt

m = -0.0024
b = 2.0798
Linear equation: y = -0.0024x + 2.0798
Accept variation in the decimal places in red

(0.1 pt each)

Depth (x)	LnPbEx-210 (y)	xy	x^2
0.5	4.7775	2.3888	0.2500
1.5	4.7168	7.0752	2.2500
9.5	4.7024	44.6728	90.2500
19.5	4.4904	87.5628	380.2500
$\Sigma x = 31.0$	$\Sigma y = 18.6871$	$\Sigma xy = 141.6996$	$\Sigma x^2 = 473.0000$

m = -0.00134
b = 4.7758
Linear equation: y = -0.00134x + 4.7758
Accept variation in the decimal places in red

3.1 (c)	Bioturbation or mixing	0.2 pt

3.1 (d) — 0.7 pt

x	Y (log)	xy	x^2
19.5	2.0179	39.3482	380.2500
29.5	1.8694	55.1486	870.2500
39.5	1.7065	67.4068	1560.2500
49.5	1.4557	72.0579	2450.2500
59.5	0.9812	58.3809	3540.2500
$\Sigma x = 197.5$	$\Sigma y = 8.0307$	$\Sigma xy = 292.3424$	$\Sigma x^2 = 8801.2500$

m = -0.0249
b = 2.5885
Linear equation: y = -0.0249x + 2.5885 (0.1 pt each)
Accept variation in the decimal places in red

x	Y (ln)	xy	x^2
19.5	4.4904	87.5628	380.2500
29.5	4.3046	126.9844	870.2500
39.5	3.9294	155.2100	1560.2500
49.5	3.3519	165.9194	2450.2500
59.5	2.2593	134.4270	3540.2500
$\Sigma x = 197.5$	$\Sigma y = 18.3355$	$\Sigma xy = 141.6996$	$\Sigma x^2 = 8801.2500$

m = -0.0541
b = 5.8060
Linear equation: y = -0.0249x + 2.5885
Accept variation in the decimal places in red
*also accept 4-point data range below

30-60 cm (log)

Σx	Σy	Σxy	Σx^2
178.0	6.0129	252.9942	8421.0000
m	b		
-0.0292	2.8006		

20-50 cm (log)

Σx	Σy	Σxy	Σx^2
138.0	7.0495	233.9615	5261.0000
m	b		
-0.0185	2.4004		

20-60 cm (ln)

Σx	Σy	Σxy	Σx^2
197.5	18.3355	670.1035	8801.2500
m	b		
-0.0541	5.8060		

30-60 cm (ln)

Σx	Σy	Σxy	Σx^2
178.0	13.8451	582.5407	8421.0000
m	b		
-0.0671	6.4487		

3.1 (e)	Sedimentation Rate: 0.5427 cm/y *Acceptable answers:* $0.4706\ \text{cm/y} < S < 0.6409\ \text{cm/y}$	0.8 pt
3.2	23 years	0.8 pt

Part 4. Cesium-137 Validation (1.0 pt)

4.1	0.4348 cm/y Acceptable answers: 0.43-0.44	0.5 pt
4.2 (a)	2.8812 Accept variation in the decimal places in red	0.3 pt
4.2 (b)	No	0.2 pt

Q2 SHIELDING ACTIVATED MATERIAL (10 pts)

Part 1. Data Collection (1.5 pts)

1.1

Isotope	Cross-Section (barns)	Natural Abundance, (%)
Cr-50	15.500 to 15.505	4.345
Mn-55	13.361 to 13.400	100
Fe-58	1.157 to 1.160	0.282
Co-59	37.410 to 37.413	100

1.0 pt

0.125 each

1.2

Isotope	Half-life (sec)
Cr-51	2.393×10^6
Mn-56	9.284×10^3 to 9.288×10^3
Fe-59	3.844×10^6 to 3.845×10^6
Co-60	1.662×10^8 to 1.663×10^8

0.5 pt

0.125 each

Part 2. Neutron Activation (2.25 pts)

2.1

Activated Product	Prompt Activity after 5 hours (Bq)
Mn-56	$(1.304 \pm 0.005) \times 10^{15}$
Fe-59	$(6.516 \pm 0.015) \times 10^9$
Co-60	$(2.469 \pm 0.001) \times 10^{10}$

1.5 pts

0.5 each

2.2 (0.75 pts; 0.25 /item)

Gamma Energy	Flux (#/cm^2-sec)
0.847 MeV	$(4.103 \pm 0.015) \times 10^{10}$
1.099 MeV	$(1.172 \pm 0.003) \times 10^{5}$
1.252 MeV	$(1.570 \pm 0.001) \times 10^{6}$

Part 3. Radiation Shielding (3.0 pts)

3.1

(a) $0.05743\ \text{cm}^2\text{g}^{-1}$ — 0.3 pt

(b) $0.46343\ \text{cm}^{-1}$ — 0.3 pt

(c) $2.15781\ \text{cm}$ — 0.3 pt

*No or wrong units = wrong

3.2 — 1.0 pt

$I = 6.436 \times 10^5\ \text{photons}/\text{cm}^2 \cdot \text{s}$

Accept variation in the decimal places in red

3.3 — 1.1 pt

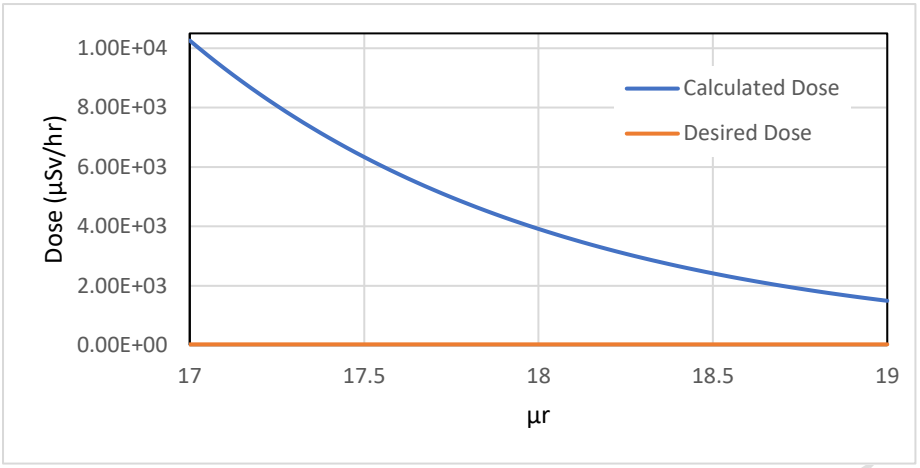
0.337 ± 0.002

Part 4. Shielding Optimization (3.25 pts)

4.1 — 0.25 pt

$25\ \frac{\mu Sv}{hr}$

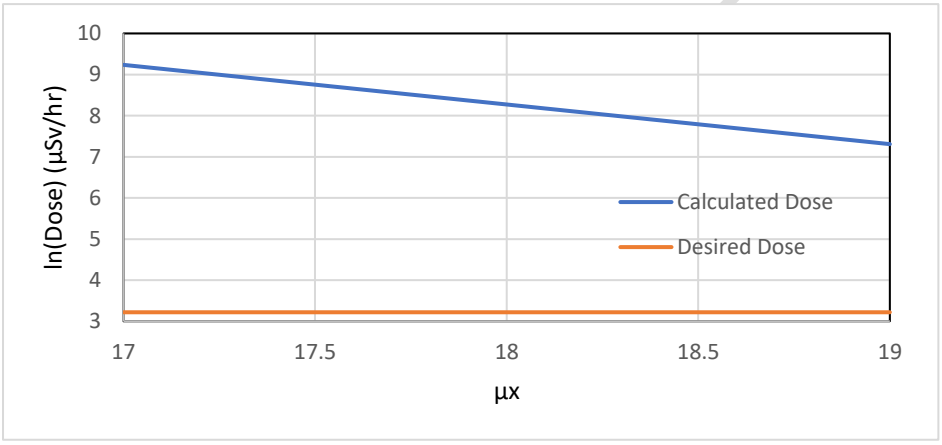
4.2 a) 2.0 pts



1.0 pt for straight line at $Dose = 25\ \mu Sv/hr$;

1.0 pt at exp plot with max of $Dose \approx 210258\ \mu Sv/hr$ and min of $Dose \approx 1490\ \mu Sv/hr$;

or



1.0 pt for straight line at $Dose \approx 3.22\ \mu Sv/hr$;

1.0 pt at exp plot with max of $Dose \approx 9.24\ \mu Sv/hr$ and min of $Dose \approx 7.31\ \mu Sv/hr$;

b) 24.629 cm or within the values [24.629 to 24.735 cm] 1.0 pt