WORKING SAFETY WITH RADIOACTIVITY

Rule	Other Considerations
1. Register as a radiation handling worker.	Before handling radioactivity, you must take education and training for radiation and health examination under the law concerning prevention from radiation hazard due to radioisotope.
2. Understand the nature of the hazard and get practical training.	Never work with unprotected cuts or breaks in the skin, particularly on the hands or forearms. Never use any mouth operated equipment in any area where unsealed radioactive material is used. Always store compounds under the conditions recommended. Label all contains clearly indicating nuclide, compound, specific activity, total activity, date and name of user. Containers should be properly sealed.
3. Contain and use radioactive materials in the controlled area.	Always keep active and inactive work separated as far as possible, preferably by maintaining rooms used solely for radioactive work. Always work over a spill tray and work in a ventilated enclosure except with small quantities of ^{3}H, ^{35}S, ^{14}C and ^{125}I compounds in a non-volatile form in solution.
4. Plan ahead to minimize time sent handling radioactivity.	Do a dummy run without radioactivity to check your procedures. The shorter the time the smaller the dose.
5. Distance yourself appropriately from sources of radiation.	Doubling the distance from the source quarters the radiation dose【Inverse Square Law】 Use appropriate tongs and tools to handle radioactive sources.
6. Use appropriate shielding for the radiation.	1cm thickness of acrylic resin will stop all betas but beware “Bremsstrahlung” from high energy beta emitters. Use suitable thickness of lead for X and gamma emitters.

7. Wear appropriate protective clothing and dosimeters.	For example, laboratory overalls, safety glasses, surgical gloves and masks. However, beware of static charge on gloves when handling fine powders. Always wear film badge (Luxel Badge) in the controlled area.
8. Monitor the work area frequently for contamination control.	In the event of a spill or a contamination, immediately ask and report to the Radiation Protection Supervisor, and follow the decontamination protocol.
9. Follow the Radiation Protection Supervisor and the local rules such as regulation on prevention of radiation hazards.	Do not eat, drink, smoke or apply cosmetics in an area where unsealed radioactive substances are handled. Use paper handkerchiefs and dispose of them appropriately. Never pipette radioactive solutions by mouth. Always work carefully and tidily.
10. Minimize accumulation of waste and dispose of it by appropriate routes.	Use the minimum quantity of radioactivity needed for the investigation. Disposal of all radioactive waste is subject to statutory control. Be aware of the requirements and use only authorized routes of disposal.
11. After completion of work-monitor yourself, wash and monitor again.	Never forget to do this. Report to the Radiation Protection Supervisor if contamination is found.
12. In the event of natural hazards –follow the prepared contingency plan.	i) Verbally warn all people in the vicinity ii) Restrict unnecessary movement into and through the area iii) Report the hazards to the Radiation Protection Supervisor iv) Treat contaminated personnel first

Practice for Safety Handling of Radioisotopes

A. Unsealed Radioisotopes-Dilution of Radioisotopes

1. Before Practice

a) Check equipments and materials on the table (Fig.1)

Fig. 1

b) Cover polyethylene paper filter on aluminum tray (Fig.2)

Fig. 2

c) Prepare waste disposal plastic bags (Fig.3)

- Combustible (papers etc.)
- Incombustible (metals, glasses, “Salan Rap” etc.)
- Less Combustible (plastic tips, plastic plates, gloves, polyethylene raps etc.)

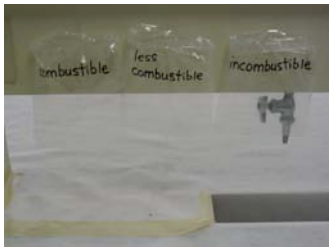


Fig. 3

d) Determination of Background activity by survey meter (adjust time- constant to 30 sec.)

2. Cold-run (Dummy-run) without radioactivity - Dilute red ink with H_2O (Fig.4)

a) Take 3 ml of H_2O in conical flask by 5 ml syringe

b) Add ab. 1 ml of H_2O though rubber cap to the glass vial

c) Pull the rod and take 1 ml of air to adjust pressure of inside/outside
d) Repeat (b) and (c)
e) Cover rubber cap with cotton and pull the syringe out of the glass vial

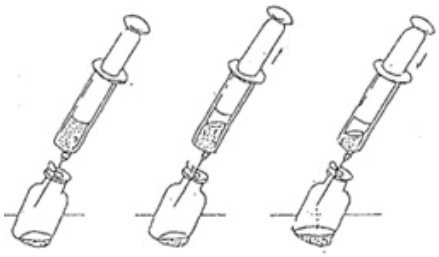


Fig. 4

3. Hot-run with radioactivity

Practice Ⅰ. Dilution of radioisotope (^{32}P) and determination of radioactivity

Don't forget to handle radioisotopes on the covered tray!!

a) Check no surface contamination of glass vial with rubber cap (^{32}P, 10 Bq/ μ l)
b) Take 100 μ l of ^{32}P (10 Bq/ μ l) using 200 μ l of pipette and mix with 1.9 ml H_2O (15 ml tube) – 20 times dilution
c) Mark group No. and sample No. on 6 plastic vials for liquid scintillation counter
d) Take 50 - 200 μ l of diluted ^{32}P solution to 4 different plastic vials (No. 2 – 5), respectively.
Take 100 μ l of ^{32}P sample solution of unknown activity to the last plastic vial (No.6) (Table 1)

Table 1

Sample No.	1	2	3	4	5	6
Diluted ^{32}P solution (μ l)	0	50	100	150	200	-
^{32}P solution of unknown activity (μ l)	-	-	-	-	-	100
Liquid scintillater (ml)	4	4	4	4	4	4

e) Add 4 ml of liquid scintillater to each vials in ventilated hood. (Fig.5)

Fig. 5

f) Count the activity by the liquid scintillation counter

g) Make a standard curve and determine the activity (Bq/ml) of the sample

Practice Ⅱ. Monitoring and determination of contamination

Ⅱ-1 Survey method

a) Cover OHP sheet with plastic rap and search 2 contaminated area with GM survey mether (time constant, 3 sec)
   Move prove of GM survey meter slowly on covered OHP sheet (not to attach the sheet!!)
b) Put exactly plastic holder on the center on the contaminated area
c) Put the probe of GM survey meter in the holder and count (N 1)
d) Cover the probe by Aluminum and count again (N 2)
e) Repeat (b) and (c) for another contaminated point
f) Find the contaminated nuclide using the decay rate by Aluminum (Table. 2) and calculate the concentration of surface contamination by following equation

$A = [(N1\text{-}Nb) / (\eta /100)] \times 1/60 \times 1/S$ (Bq/cm^2)

N1: Counting rate of contaminated area (cpm)
Nb: Background counting rate (cpm)
S : Surface area (4.9 cm^2)
η : Counting efficiency of GM survey meter (Table 3)

Table 2. Decay rate by Aluminum (3 mg/ cm^2)

Nuclide	^{32}P	^{14}C/^{35}S	^{3}H	^{204}Tl	^{45}Ca
Decay rate	0.96	0.40	0	-	0.70

Table 3. Counting efficiency (η) of GM survey meter

Nuclide	^{32}P	^{14}C/^{35}S	^{3}H	^{204}Tl	^{45}Ca
Counting efficiency (%)	20.6	2.3	>0.1	15.7	6.3

Ⅱ-2 Smear method

a) Cover the board with plastic rap and search most contaminate point in the area A by GM survey meter (time constant, 3 sec)

b) Put the plastic holder and the probe of GM survey meter on the point, and count the activity (time constant, 30 sec) (N 1)
c) Remove the rap, wet the smear paper and wipe thoroughly the area A (10×10cm) by hand
d) Put the round portion of the smear paper in the plastic scintillation vial
e) Add 4 ml of scintillater to the vial and count by the liquid scintillation counter (Nsc)
f) Cover the board again with the plastic rap and count the activity (N 2)
g) Calculate the wiping efficiency by the following equation

$D(\%) = [(N1 - N2) / (N1 - Nb)] \times 100$

N1: Counting rate before wiping (cpm)
N2: Counting rate after wiping (cpm)
Nb: Background (cpm)

h) Calculate the concentration of surface contamination by the following equation

$A\ (Bq/cm^2) = (Nsc - Nb) / [(\eta/100) \times S \times (D/100) \times 60]$

Nsc : Counting rate (cpm)
Nb: Background count by liquid scintillation (cpm)
η : Counting efficiency of liquid scintillation counter
S : Contaminated area (100 cm^2)
D: Wiping efficiency (%)

4. After practice - Clear the work area

a) Monitor the all equipment and the work area
b) Disposed of wastes by the appropriate routes

B. Sealed Radioisotopes

Practice Ⅲ. Shielding of β ray - Absorption curve of β ray

Radiation source, $^{90}Sr/^{90}Y$ (E max = 2.282 Mev)

a) Read the Background count (cpm)
b) Insert the acrylic resin plate (0,1,3,5,7 and 9 mm thickness) between radiation source and the detector
c) Read the counting rate (cpm), respectively
d) Plot the net counting rate (cpm) as Y - axis (log) and the thickness of acrylic resin (mm) as Y - axis (linear)

e) Determine the thickness of acrylic resin needed for complete shielding of β ray

Practice Ⅳ. Shielding of γ ray

Radiation source, ^{60}Co (1.17MeV, 1.33MeV)

a) Put the lead plate (1 - 5 cm thickness) between radiation source and the detector and count
b) Record the respective count and understand the shielding effect of lead plate
c) Compare the effective shielding of lead with 5cm thickness of acrylic resin plate

Report

Group No._____ Date_____

Name_____

Practice Ⅰ. Dilution of radioisotope and determination of radioactivity of sample

Background (BG, survey meter) _____(cpm)

Background (BG, liquid scintillation counter)_____(cpm)

Counting rate	Vial No.					
	1	2	3	4	5	6
net cpm*1	0					
net dpm*2	0					

*1 net cpm, Subtract BG count (cpm, count per minute) from sample's count (cpm) measured by liquid scintillation counter

*2 net dpm, Decay per minute – calculate from concentration of standard radioisotope (Bq/μl)

Plot net cpm as Y-axis and net dpm as X-axis and determine the activity of sample.

Counting efficiency, slope of the curve.

Activity of sample_____Bq (dps) / ml

Counting efficiency of ^{32}P _____%

Practice Ⅱ. Monitoring and determination of contamination

BG count (survey meter)_____(cpm)

Plate No._____

	A	B	C	D	E	F
1						
2						
3						
4						
5						
6						

※Check contaminated point

Ⅱ-1. Survey method

Contaminated Point	Net cpm N1-Nb (cpm)	Net cpm N2-Nb (cpm)	(N2-Nb) / (N1-Nb)	Estimated Nuclide	Concentration of surface contamination(Bq/cm²)

Ⅱ-2. Smear method

Sample plate	Sample No.	Net cpm before smear N1-Nb (cpm)	Net cpm after smear N2-Nb (cpm)	Wiping efficiency (%)	Count rate by liquid scintillation counter (cpm)	Concentration of surface contamination (Bq/cm²)

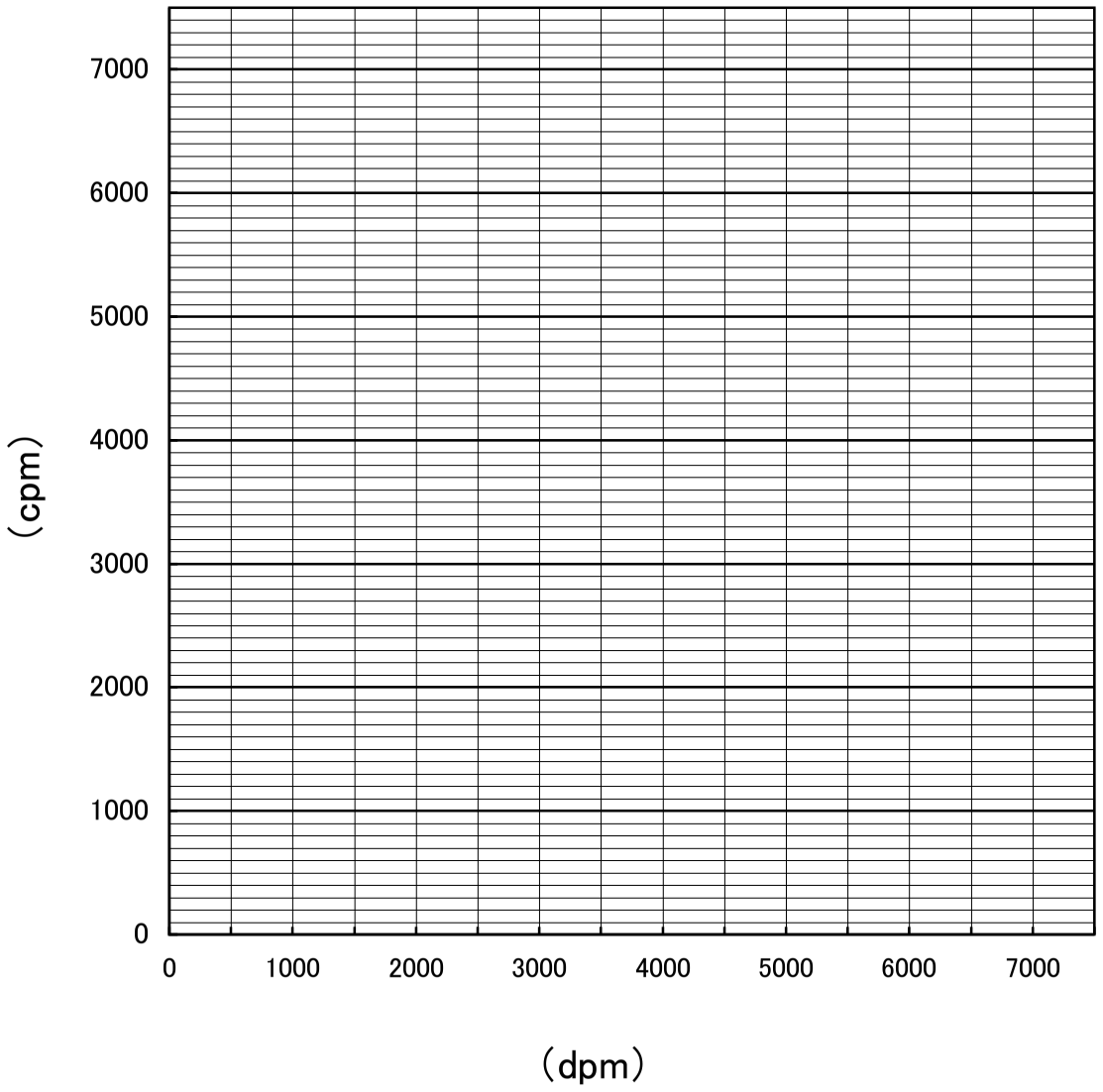
Practice Ⅲ. Shielding of β ray

Thickness of acrylic resin plate (mm)	cpm	Net cpm (cpm – BG cpm)
0		
1		
3		
5		
7		
9		
Background (cpm)		Thickness for complete shielding of β ray

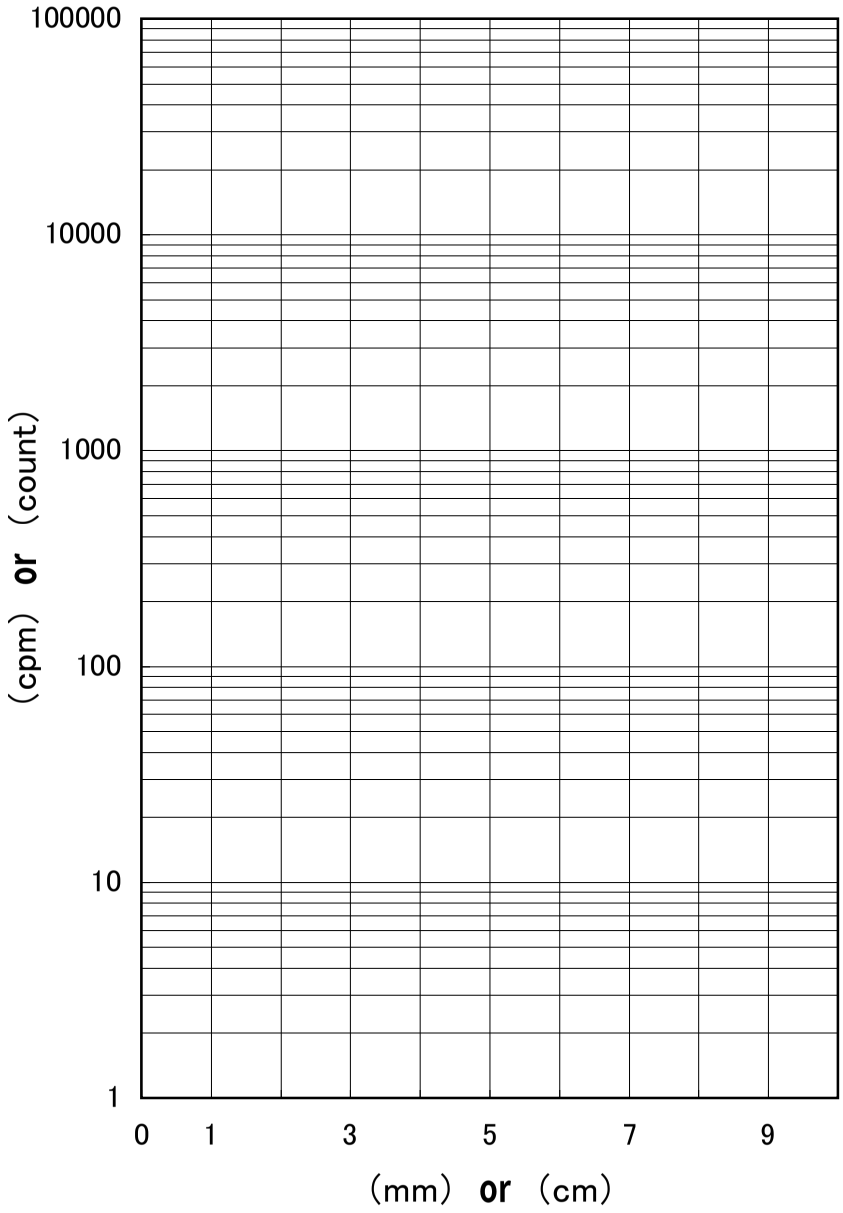
Practice Ⅳ. Shielding of γ ray

Thickness of Lead plate (cm)	count
0	
1	
2	
3	
4	
5	
Acrylic resin plate (5cm)	

Ⅰ.


7000
6000
5000
4000
3000
2000
1000
0
(cpm)
0
1000
2000
3000
4000
5000
6000
7000
(dpm)

Ⅲ,Ⅳ.


100000
10000
1000
100
10
1
(cpm) or (count)
0
1
3
5
7
9
(mm) or (cm)