Calcium-45

Ca

WORKING SAFELY WITH CALCIUM-45

Radioactive half-life $T_{1/2}$	163 days
Principal emissions	0.257 MeV beta (maximum)
Monitoring for contamination	End-window Geiger-Müller detector
Biological Monitoring	Urine
Annual Limit on Intake (ALI) by inhalation (most restrictive)	3×10^7 Bq (~1mCi)**
Maximum range in air	52 cm
Maximum range in water	0.62 mm
Shielding	1 cm Perspex / Plexiglas cuts out all betas

DAYS	0	5	10	15	20	25	30
0	1.000	0.979	0.959	0.939	0.919	0.900	0.881
35	0.863	0.844	0.827	0.810	0.793	0.776	0.760
70	0.744	0.728	0.713	0.698	0.684	0.669	0.655
105	0.642	0.628	0.615	0.602	0.590	0.577	0.565
140	0.553	0.542	0.531	0.519	0.509	0.498	0.488
175	0.477	0.467	0.458	0.448	0.439	0.430	0.421
210	0.412	0.403	0.395	0.386	0.378	0.370	0.363
245	0.355	0.348	0.340	0.333	0.326	0.320	0.313
280	0.306	0.300	0.294	0.287	0.281	0.276	0.270
325	0.253	0.248	0.243	0.238	0.233	0.228	0.223
360	0.218	0.214	0.209	0.205	0.201	0.197	0.192

DAYS

Special Considerations

In general Calcium-45 does not require any special precautions over and above those necessary for any beta-emitting radionuclide of this energy of emissions. The majority of Calcium-45 is deposited in the bone and is retained with a long biological half life.

** Based on occupational effective dose equivalent limit of 50 mSv for stochastic risks. In Germany the ALI value is 2×10^7 Bq.
The Annual Limit on Intake (ALI) data are based on the recommendations of the International Commission on Radiological Protection (ICRP) Publication 30 but may change should the ICRP Publication 60 recommendations be adopted by your national regulatory authority.

The data provided is general information which gives a basic understanding of radiation safety. You must however consult your local radiation protection adviser to ensure that you comply with all national regulations and local rules.

Carbon-14

WORKING SAFELY WITH CARBON-14

Radioactive half-life $T_{1/2}$	5730 years
Principal emission	0.156 MeV beta (maximum)
Monitoring for contamination	Thin end - window Geiger-Müller detector
Biological Monitoring	Urine samples Breath measurements (CO_2)
Annual Limit on Intake (ALI) by ingestion	9×10^7 Bq (~2.4mCi) ** (Labelled Organic Compounds)
Maximum range in air	24 cm
Maximum range in water	0.28 mm
Shielding	1 cm Perspex / Plexiglas. Thinner Perspex / Plexiglas down to 3 mm, although adequate to reduce doses, does not have good mechanical properties.

Special Considerations

There is a possibility that some organic compounds can be absorbed through gloves. Care needs to be taken not to generate carbon dioxide which could be inhaled.

** Based on occupational effective dose equivalent limit of 50 mSv for stochastic risks

The Annual Limit on Intake (ALI) data are based on the recommendations of the International Commission on Radiological Protection (ICRP) Publication 30 but may change should the ICRP Publication 60 recommendations be adopted by your national regulatory authority.

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Chromium-51

WORKING SAFELY WITH CHROMIUM-51

Radioactive half-life $T_{1/2}$	27.7 days
Principal emissions	0.32 MeV gamma (9.8%) 5keV X-ray (22% V-51 K X-rays)
Monitoring for contamination	Scintillation detector
Biological Monitoring	Whole body
Annual Limit on Intake (ALI) by inhalation (most restrictive)	7×10^8 Bq (~20mCi)**
Dose rate from 1 GBq point source at 1m	4.7 µSv/h (0.47 mrem/h)
First half value layer	3 mm lead (approx)

DAYS	0	1	2	3	4	5	6
	1.000	0.975	0.951	0.927	0.904	0.881	0.859
7	0.838	0.817	0.796	0.777	0.757	0.738	0.720
14	0.702	0.684	0.667	0.651	0.634	0.618	0.603
21	0.588	0.573	0.559	0.545	0.531	0.518	0.505
28	0.493	0.480	0.468	0.457	0.445	0.434	0.423
35	0.413	0.402	0.392	0.382	0.373	0.364	0.355
42	0.346	0.337	0.329	0.320	0.312	0.305	0.297
49	0.290	0.282	0.275	0.268	0.262	0.255	0.249
56	0.243	0.237	0.231	0.225	0.219	0.214	0.208
63	0.203	0.198	0.193	0.188	0.184	0.179	0.175

DAYS

Special Considerations

In general Chromium-51 does not require any special precautions over and above those necessary for any radionuclide of this energy of emissions.Chromium-51 in the form of chromate is not selectively absorbed by any organ in the body.

** Based on occupational effective dose equivalent limit of 50 mSv for stochastic risks In Germany the ALI value is 3×10^8 Bq.
The Annual Limit on Intake (ALI) data are based on the recommendations of the International Commission on Radiological Protection (ICRP) Publication 30 but may change should the ICRP Publication 60 recommendations be adopted by your national regulatory authority.

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Iodine-125

WORKING SAFELY WITH IODINE-125

Radioactive half-life $T_{1/2}$	59.6 days
Principal Emissions	35 keV gamma (7% emitted, 93% internally converted) 27-32 keV X-rays (140% Te K X- rays)
Monitoring for contamination	Scintillation detector
Biological Monitoring	Thyroid scans (scintillation detector)
Annual Limit on Intake (ALI) by inhalation	2×10^6 Bq (~55µCi)*
Dose rate from 1 GBq point source at 1m	41 µSv/h (4.1 mrem/h)
First half value layer	0.02 mm lead

DAYS	0	2	4	6	8	10	12	14	16	18
0	1.000	0.977	0.955	0.933	0.911	0.890	0.870	0.850	0.830	0.811
20	0.793	0.774	0.756	0.739	0.722	0.706	0.689	0.673	0.658	0.643
40	0.628	0.614	0.600	0.586	0.572	0.559	0.546	0.534	0.521	0.509
60	0.498	0.486	0.475	0.464	0.454	0.443	0.433	0.423	0.413	0.404
80	0.394	0.385	0.377	0.368	0.359	0.351	0.343	0.335	0.328	0.320
100	0.313	0.305	0.298	0.292	0.285	0.278	0.272	0.266	0.260	0.254
120	0.248	0.242	0.236	0.231	0.226	0.221	0.215	0.211	0.206	0.201
140	0.196	0.192	0.187	0.183	0.179	0.175	0.171	0.167	0.163	0.159
160	0.156	0.152	0.149	0.145	0.142	0.139	0.135	0.132	0.129	0.126
180	0.123	0.120	0.118	0.115	0.112	0.110	0.107	0.105	0.102	0.100
200	0.098	0.095	0.093	0.091	0.089	0.087	0.085	0.083	0.081	0.079
220	0.077	0.076	0.074	0.072	0.071	0.069	0.067	0.066	0.064	0.063
240	0.061	0.060	0.059	0.057	0.056	0.055	0.053	0.052	0.051	0.050

DAYS

Special Considerations

Volatilization of iodine is the most significant problem with this isotope. Simply opening a vial of sodium [^{125}I] iodide at high radioactive concentration can cause minute droplets of up to 100Bq to become airborne. Solutions containing iodide ions should not be made acidic nor stored frozen: both lead to formation of volatile elemental iodine. As some iodo-compounds can penetrate surgical rubber gloves it is advisable to wear two pairs, or polythene (polyethylene) gloves over rubber. In the event of suspected or actual significant contamination of personnel the thyroid should be blocked by administration of stable iodine as, for example, tablets of potassium iodate (170mg) or potassium iodide (130mg). To render any spilled iodine-125 chemically stable the area of the spill should be treated with alkaline sodium thiosulphate solution prior to commencing decontamination. Note, however, that the quantity of radioiodine in normal RIA kits (usually <370 kBq or 10µCi) is such that these can be handled safely with reasonable care on the open bench.

* Based on occupational dose equivalent limit of 500 mSv for deterministic (non-stochastic) risks to the thyroid. In Germany the ALI value is 8×10^5 Bq

The Annual Limit on Intake (ALI) data are based on the recommendations of the International Commission on Radiological Protection (ICRP) Publication 30 but may change should the ICRP Publication 60 recommendations be adopted by your national regulatory authority.

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SAFE AND SECURE

Phosphorus-32

WORKING SAFELY WITH PHOSPHORUS-32

Radioactive half-life $T_{1/2}$	14.3 days
Principal emission	1.709 MeV beta (maximum)
Monitoring for contamination	Geiger-Müller detector
Biological Monitoring	Urine samples
Annual Limit on Intake (ALI) by inhalation	3×10^7 Bq (~1mCi) ** (Class D)
Maximum range in air	790 cm
Maximum range in water	0.8 cm
Dose rate from 1 MBq in 1 ml	210mSv/h (21rem/h) at surface 2.5µSv/h (0.25mrem/h) at 1 m
Shielding	1 cm Perspex (Plexiglas) cuts out betas and minimises production of Bremsstrahlung

DAYS \ HOURS	0	12	24	36	48	60	72	84
0	1.000	0.976	0.953	0.930	0.908	0.886	0.865	0.844
4	0.824	0.804	0.785	0.766	0.748	0.730	0.712	0.695
8	0.679	0.662	0.646	0.631	0.616	0.601	0.587	0.573
12	0.559	0.546	0.533	0.520	0.507	0.495	0.483	0.472
16	0.460	0.449	0.439	0.428	0.418	0.408	0.398	0.389
20	0.379	0.370	0.361	0.353	0.344	0.336	0.328	0.320
24	0.312	0.305	0.298	0.291	0.284	0.277	0.270	0.264
28	0.257	0.251	0.245	0.239	0.234	0.228	0.223	0.217
32	0.212	0.207	0.202	0.197	0.192	0.188	0.183	0.179
36	0.175	0.170	0.166	0.162	0.159	0.155	0.151	0.147
40	0.144	0.140	0.137	0.134	0.131	0.127	0.124	0.121
44	0.119	0.116	0.113	0.110	0.108	0.105	0.102	0.100
48	0.098	0.095	0.093	0.091	0.089	0.086	0.084	0.082
52	0.080	0.078	0.077	0.075	0.073	0.071	0.070	0.068

Special Considerations

Phosphorus-32 is the highest energy radionuclide commonly encountered in research laboratories and as such requires special care. Avoid exposure e.g. do not hold tubes containing even small quantities of ^{32}P any longer than necessary - use a stand or holder. If quantities greater than a few tens of MBq (around a mCi) are used, wrist and finger dosimeters should be worn. Remember wrist badges alone may fail to indicate high dose to the finger tips. The use of lead-impregnated rubber gloves is also recommended. Even with low-density materials (for example, Perspex / Plexiglas) the absorption of the beta-particles gives rise to relatively high energy Bremsstrahlung which may require some lead shielding when quantities greater than a few hundred MBq (or tens of millicuries) are being handled.

** Based on occupational effective dose equivalent limit of 50 mSv for stochastic risks. In Germany the ALI value is 6×10^6 Bq.

The Annual Limit on Intake (ALI) data are based on the recommendations of the International Commission on Radiological Protection (ICRP) Publication 30 but may change should the ICRP Publication 60 recommendations be adopted by your national regulatory authority.

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SAFE AND SECURE

Phosphorus-33

WORKING SAFELY WITH PHOSPHORUS-33

Radioactive half-life $T_{1/2}$	25.4 days
Principal emission	0.249MeV beta (maximum)
Monitoring for contamination	Geiger-Müller detector
Biological monitoring	Urine samples
Annual limit on intake (ALI) by inhalation	3×10^8Bq (~10mCi)**(Class D)
Maximum range in air	49cm
Maximum range in water	0.6mm
Shielding	1cm Perspex (Plexiglas) cuts out betas. Thinner Perspex/Plexiglas down to 3 mm, although adequate to reduce doses, does not have good mechanical properties.

DAYS	0	1	2	3	4	5	6	7	8	9
0	1.000	0.973	0.947	0.921	0.897	0.872	0.849	0.826	0.804	0.782
10	0.761	0.741	0.721	0.701	0.683	0.664	0.646	0.629	0.612	0.595
20	0.579	0.564	0.549	0.534	0.520	0.506	0.492	0.479	0.466	0.453
30	0.441	0.429	0.418	0.406	0.395	0.385	0.374	0.364	0.355	0.345
40	0.336	0.327	0.318	0.309	0.301	0.293	0.285	0.277	0.270	0.263
50	0.256	0.249	0.242	0.236	0.229	0.223	0.217	0.211	0.205	0.200
60	0.195	0.189	0.184	0.179	0.174	0.170	0.165	0.161	0.156	0.152
70	0.148	0.144	0.140	0.136	0.133	0.129	0.126	0.122	0.119	0.116
80	0.113	0.110	0.107	0.104	0.101	0.098	0.096	0.093	0.091	0.088
90	0.086	0.084	0.081	0.079	0.077	0.075	0.073	0.071	0.069	0.067
100	0.065	0.064	0.062	0.060	0.059	0.057	0.055	0.054	0.053	0.051

DAYS

Special considerations

In general, phosphorus-33 does not require special precautions over and above those necessary for any beta-emitting radionuclide of this energy of emissions.

** Based on occupational effective does equivalent limit of 50 mSv for stochastic risks
In Germany, the ALI value is: 4×10^7Bq for phosphates of Zn, Sn, Mg, Bi, lanthanides. 1×10^8Bq for all other phosphates.

Annual Limit on Intake (ALI) data are based on the recommendations of the International Commission on Radiological Protection (ICRP) Publication 30 but may change should the ICRP Publication 60 recommendations be adopted by your national regulatory authority. The data provided is general information which gives a basic understanding of radiation safety. You must, however, consult your local radiation protection adviser to ensure that you comply with all national regulations and local rules.

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SAFE AND SECURE

Sulphur-35

WORKING SAFELY WITH SULPHUR-35

Radioactive half-life $T_{1/2}$	87.4 days
Principal emission	0.167 MeV beta (maximum)
Monitoring for contamination	Thin end-window Geiger-Müller detector
Biological Monitoring	Urine samples
Annual Limit on Intake (ALI) by ingestion	4×10^8 Bq (~10mCi) ** (Inorganic compounds) 2×10^8 Bq (~5mCi) * (Elemental sulphur)
Maximum range in air	26 cm
Maximum range in water	0.32 mm
Shielding	1 cm Perspex / Plexiglas.Thinner Perspex / Plexiglas down to 3mm, although adequate to reduce doses, does not have good mechanical properties.

WEEKS \ DAYS	0	1	2	3	4	5	6
0	1.000	0.992	0.984	0.976	0.969	0.961	0.954
1	0.946	0.939	0.931	0.924	0.916	0.909	0.902
2	0.895	0.888	0.881	0.874	0.867	0.860	0.853
3	0.847	0.840	0.833	0.827	0.820	0.814	0.807
4	0.801	0.795	0.788	0.782	0.776	0.770	0.764
5	0.758	0.752	0.746	0.740	0.734	0.728	0.722
6	0.717	0.711	0.705	0.700	0.694	0.689	0.683
7	0.678	0.673	0.667	0.662	0.657	0.652	0.646
8	0.641	0.636	0.631	0.626	0.621	0.616	0.612
9	0.607	0.602	0.597	0.592	0.588	0.583	0.579
10	0.574	0.569	0.565	0.560	0.556	0.552	0.547
11	0.543	0.539	0.534	0.530	0.526	0.522	0.518
12	0.514	0.510	0.506	0.502	0.498	0.494	0.490

Special Considerations

Note that organic compounds are often strongly retained and no limits of exposure have been set for them. Care also needs to be taken not to generate sulphur dioxide or hydrogen sulphide which could be inhaled. Radiolysis of ^{35}S-amino acids during storage and use may lead to the release of ^{35}S-labelled volatile impurities. Although the level of these impurities is small (typically less than 0.05%) contamination of the internal surfaces of storage and reaction vessels may occur. Vials should be opened and used in ventilated enclosures.

** Based on occupational effective dose equivalent limit of 50 mSv for stochastic risks In Germany the ALI value is 3×10^8 Bq
* Based on occupational effective dose equivalent limit of 500 mSv for deterministic risks. In Germany the ALI value is 7×10^7 Bq
The Annual Limit on Intake (ALI) data are based on the recommendations of the International Commission on Radiological Protection (ICRP) Publication 30 but may change should the ICRP Publication 60 recommendations be adopted by your national regulatory authority.

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SAFE AND SECURE

Tritium ^3H

WORKING SAFELY WITH TRITIUM ^3H

Radioactive half-life $T_{1/2}$	12.4 years
Principal emission	18.6 keV beta (maximum)
Monitoring for contamination	Swabs counted by liquid scintillation
Biological Monitoring	Urine samples
Annual Limit on Intake (ALI) ingestion or inhalation	3×10^9 Bq (~80mCi) ** (tritiated water)
Maximum range in air	6mm
Maximum range in water	6×10^{-3} mm
Shielding required	None

Special Considerations

Tritium, because of its low beta-energy, cannot be monitored directly and therefore especial care is needed to keep the working environment clean and tidy. Regular monitoring by counting swabs is advisable in areas where this nuclide is used. Tritium can be absorbed through the skin. Appropriate gloves should be worn. External contamination, although not causing a radiation dose itself, should be kept as low as possible as it can lead to internal and hence hazardous contamination; it can also interfere in experimental results. DNA precursors eg tritiated thymidine are regarded as more toxic than tritiated water partly because activity is concentrated into cell nuclei. This is reflected by lower ALIs for the material in this form.(refer to ICRP 30).

** Based on occupational effective dose equivalent limit of 50 mSv for stochastic risks

The Annual Limit on Intake (ALI) data are based on the recommendations of the International Commission on Radiological Protection (ICRP) Publication 30 but may change should the ICRP Publication 60 recommendations be adopted by your national regulatory authority.

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