Indium-111	2.81 d	e.c.		100 %	0.172 0.247	89.6 % 94.0 %	10.4 % 6.0 %
Indium-113m	99.5 min	i.t.		100 %	0.392 0.024–0.028	64.9 % 24 % (In K X-rays)	35.1 %
Iodine-123	13.2 h	e.c.		100 %	0.159 0.347 0.440 0.506 0.529 0.539 0.027–0.032	83.0 % 0.10 % 0.35 % 0.26 % 1.05 % 0.27 % ~86 % (Te K X-rays)	16.3 %
Iodine-125	60.0 d	e.c.		100 %	0.035 0.027–0.032	7 % 138 % (Te K X-rays)	93 %
Iodine-126	13 d	β^-	0.38 0.88 1.27	3 % 30 % 15 %	0.389 0.491 0.511	32 % 2 % from β^+	0.5 %
		β^+	0.46 1.1	~0.1 % ~0.4 %	0.666 0.754	30 % 4 %	0.1 %
		e.c.		51.5 %	0.880 1.420 others 0.027–0.032	0.8 % 0.3 % <0.1 % each ~38 % (Te K X-rays)	
Iodine-131	8.06 d	β^-	0.247 0.304 0.334 0.606 0.806	1.8 % 0.6 % 7.2 % 89.7 % 0.7 %	0.080 0.284 0.364 0.637 0.723	2.4 % 5.9 % 81.8 % 7.2 % 1.8 %	3.8 % 0.3 % 1.7 %
		1.3 % of ^{131}I decays via 12 d ^{131m}Xe					
(Xenon-131m)		i.t.		100 %	0.164	2 %	98 %
					(percentages relate to disintegrations of ^{131m}Xe)		

[a] μs = microsecond; ms = millisecond; s = second; min = minute; h = hour; d = day; a = year.
[b] e.c. = electron capture; i.t. = isomeric transition.

employing liquid or solid phosphors may be used for the measurement of alpha, beta, and gamma emitters. Solid-state devices may also be used for alpha, beta, and gamma measurements. The electronic circuitry associated with a detector system usually consists of a high-voltage supply, an amplifier, a pulse-height selector, and a scaler, a ratemeter, or other readout device. When the electronic scaling device or the scaler in a counting assembly is replaced by an electronic integrating device, the resultant assembly is a ratemeter. Ratemeters are used for the purpose of monitoring and surveying radioactivity and are somewhat less precise as measuring instruments than the counters. Ionization chambers are often used for measuring gamma-ray activities and, provided they are thin-walled, for measuring X-rays.

Radiation from a radioactive source is emitted in all directions. Procedures for the standardization and measurement of such sources by means of a count of the emissions in all directions are known as 4π-counting; those based on a count of the emissions in a solid angle of 2π steradians are known as 2π-counting; and those based on a fraction of the emissions defined by the solid angle subtended from the detector to the source are known as counting in a fixed geometry. It is customary to assay the radioactivity of a preparation by comparison with a standardized preparation using identical geometry conditions. The validity of such an assay is critically dependent upon the reproducibility of the spatial relationships of the source to the detector and its surroundings and upon the accuracy of the standardized preparation. In the primary standardization of radionuclides coincidence techniques are employed in preference to simple 4π-counting whenever the decay scheme of the radionuclide permits. One of the most commonly employed coincidence techniques is 4π-beta/gamma coincidence counting, which is used for nuclides in which some or all of the disintegrations are followed by prompt photon emission. An additional adjacent detector, sensitive only to photons, is used to measure the efficiency in the 4π-counter of those disintegrations with which the photons are coincident. 4π-Gamma/gamma coincidence counting techniques are often employed for the standardization of pure gamma emitters.

The construction and performance of instruments and accessory apparatus vary. The preparation of samples must be modified to obtain satisfactory results with a particular instrument. The operator must follow carefully the manufacturer's instructions for optimum instrument performance and substantiate results by careful examination of known samples. Proper instrument functioning and reliability must be monitored on a day-to-day basis through the use of secondary reference preparations.

Radioactivity due to materials of construction, to cosmic rays, and to spontaneous discharges in the atmosphere contributes what is known

Other Requirements

Radiopharmaceuticals administered parenterally should comply with the relevant requirements for injections in the *International Pharmacopoeia*, except that they are not subject to the requirements concerning volume of injection in a single-dose container.

Expiry Date

The special nature of a radiopharmaceutical requires that it be assigned an expiry period (or an expiry date), beyond which its continued use is not recommended. The expiry period so designated begins with the date at which the radioactivity is expressed on the label, and may be stated in terms of days, weeks or months. For longer-lived radionuclides, the expiry period does not exceed 6 months. The expiry period depends on the radiochemical stability and the content of longer-lived radionuclidic impurity in the preparation under consideration. At the end of the expiry period, the radioactivity will have decreased to the extent where insufficient radioactivity remains to serve the intended purpose or where the dose of active ingredient must be increased so much that undesirable physiological responses occur. In addition, chemical or radiation decomposition may have reduced the radiochemical purity to an unacceptable extent. Also the radionuclidic impurity content may be such that an unacceptable radiation dose would be delivered to the patient. The use of products beyond their expiry periods is therefore inadvisable.

Labelling

In general, the following information should appear on the immediate container (for example, vial):

(1) the name of the preparation;

(2) a statement that the product is radioactive;

(3) the name and location of the manufacturer;

(4) the total radioactivity present at a stated date and hour (whenever the half-life period is more than 30 days only the date need be stated);

(5) the expiry date or the expiry period;

(6) a number or other indication by which the history of the product may be traced (for example, batch or lot number);

Their specific capacity may vary from 2 to 5 millimoles per gram (dry basis). In practice, a large (200-300 %) excess of resin is used over the calculated stoichiometric requirement.

The laws governing the exchange reaction are complex, being in part described by mass action, ionic charge, and activity relationships. The selectivity coefficient is used to indicate the preference of the ion-exchange resin for the uptake of 2 (or more) ions from solution. Generally speaking, the resin will take up divalent (or higher) ions in preference to monovalent ions, and in the case of a choice between ions of the same valence, the resin will take up the heavier ion preferentially.

Treatment of the ion-exchange resin and preparation of the column. Usually the ion-exchange resin is immersed in water and allowed to swell for 24 hours; it is then packed into a suitable column and, in the case of an anion-exchange resin, converted to the basic form by passing sodium hydroxide (~80 g/l) TS through the column at a rate of about 3 ml per minute until the effluent is free of chloride, followed by carbon-dioxide-free water, R to remove alkalinity. In the case of a cation-exchange resin, conversion to the acidic form is achieved by passing hydrochloric acid (~70 g/l) TS through the column, followed by carbon-dioxide-free water R until the washings are neutral.

The prepared column is used in a similar manner to that described for adsorption column chromatography except that there is usually no need to monitor the effluent; according to the type of resin chosen and the type of material being determined the volume of effluent detailed in the particular application is collected and titrated with acid or base as appropriate, using a suitable indicator.

After the determination has been completed, the ion-exchange column may be regenerated by washing either with sodium hydroxide (~80 g/l) TS, for an anion-exchange column, or hydrochloric acid (~70 g/l) TS, for a cation-exchange column, followed by water until a neutral reaction is obtained.

High-pressure Liquid Chromatography

This most recently introduced method of chromatography has brought column chromatography, the oldest form of the art, back into prominence. The essential development that has made the technique possible has been the availability of highly pressure-resistant particles of uniform diameters of less than 50 μm. These particles commonly have a solid centre, for example, of glass, and a thin porous outer layer, for example, of silica; the small particle size and high surface area so obtained confer a very high efficiency for use in adsorption chromatography. When these particles are coated with a suitable stationary phase, high-pressure liquid chromatography may be used as a partition technique.