Australasian College of Physical Scientists and Engineers in Medicine
Australasian Radiation Protection Society
Australian Institute of Occupational Hygienists Incorporated

Accreditation in Ionising Radiation Safety within Australia and New Zealand

Candidate's Kit Version 9, February 2009

Australasian Radiation Protection Accreditation Board Inc:
c/o Dr D A Causer
Chair, ARPAB
Physicist I/C Clinical Physics
Royal Perth Hospital
PO Box X2213, Perth WA 6001 Australia
e-mail: david.causer@health.wa.gov.au

Index

1. Introduction

This document describes requirements for Accreditation in Ionising Radiation Safety within Australia and New Zealand. This accreditation scheme has been designed as an appropriate level of study and experience for professionals undertaking the duties of a Radiation Protection Advisor as defined in Sections 2 and 4 below. The required reading and practical experience are intended as a broad introduction to the technical principles that will be used throughout a career in radiation safety.

The Accreditation in Ionising Radiation Safety within Australia and New Zealand is sponsored by the following professional societies:

- Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM),
- Australasian Radiation Protection Society (ARPS), and
- Australian Institute of Occupational Hygienists Incorporated (AIOH).

The Accreditation in Ionising Radiation Safety within Australia and New Zealand is administered by the **Australasian Radiation Protection Accreditation Board Inc** herein referred to as **The Board.** The board consists of two members appointed by each of the Sponsoring Societies. The Board elects its own Chairman and appoints Examiners as required. Accreditation is available to members of the three Sponsoring Societies.

It is envisaged that many candidates will be recent graduates in science or engineering. The standard for accreditation has been set so that with part-time study they can complete the syllabus and gain accreditation within one year of taking up an appointment in which they can gain relevant experience. Other graduates and non-graduates will be accepted as candidates provided they can show adequate evidence that they have the ability to achieve the required entrance standard which includes skills in physics, chemistry, mathematics, computation, anatomy and physiology. Nongraduate candidates should contact the Chairperson to discuss their entrance to the course; they will be assessed on the basis of other relevant courses, examinations and professional activities that they have completed.

To obtain accreditation, all candidates will be required to complete both a theoretical and a practical component of study.

In order to complete the theoretical component of the accreditation, a candidate must:

1.1 satisfy the Board that he/she has a suitable level of education,
1.2 complete a self-paced reading and numerical problem solving program,
1.3 pass a written examination based on the prescribed reading material and the requirement for adequate skills in numerical computation,

In order to complete the practical component of the accreditation, a candidate must:

1.4 gain practical experience in the use of radiation monitoring equipment,

1.5 complete an assignment (approximately 5000 words) in which the candidate prepares a radiation protection program for a nominated institution or commercial operation,
1.6 complete twelve months relevant experience preferably under the supervision of an accredited Radiation Protection Advisor,
1.7 pass a practical examination in the use of monitoring equipment,
1.8 defend the presented radiation protection program at an oral examination/interview (generally held in conjunction with the practical examination) and satisfy the examiners that he/she is able to perform the duties of a Radiation Protection Advisor.

Accreditation in Ionising Radiation Safety is for a period of three years. In order to maintain their accreditation for a further three years, candidates must demonstrate that they are actively maintaining their expertise as described below.

Candidates are required to pay Application, Examination and Maintenance Fees as listed in Appendix C. These fees have been set to recover the costs associated with the conduct of the examinations and the expenses of the Board. The fees are determined by the Board and are subject to change from time to time as determined by The Board.

2. Relationship to Other Accreditation Schemes and Professional Levels

Table 1 lists the accreditation schemes relating to radiation as offered by the Sponsoring Societies (current in 2000).

Table 1
Accreditation & Certification Schemes
Offered by ACPSEM, AIOH and ARPS

Name of Accreditation	Sponsoring Societies
Accreditation in Ionising Radiation Safety within Australia and New Zealand	ACPSEM, ARPS & AIOH
Accreditation in Radiological Physics	ACPSEM
Accreditation in Radiotherapy Equipment Commissioning and Quality Assurance	ACPSEM
Certification in Mammography Equipment Testing to the Standard Defined by the RACR* Accreditation Requirements	ACPSEM School of Medical Radiation Technology University of Sydney

* Royal Australasian College of Radiologists

Within Australia and New Zealand it is possible to divide those providing radiation safety services into three broad classifications:

2.1 Radiation Safety Officer,
2.2 Radiation Protection Advisor, and

2.3 Professional Health Physicist.

Radiation Safety Officers comprise a large group of people who provide essential radiation safety services on a daily basis in workplaces ranging from the individual departments of large institutes to enterprises such as a small factory where there may be just a single radiation gauge. They may be technical officers or foremen. Under the legislation in some states they will be the nominated officer responsible for the safety of the practice. They are not expected to have the breadth of knowledge of a Radiation Protection Advisor and they may be subject to supervision or inspection by a Radiation Protection Advisor. The appropriate level of training for a Radiation Safety Officer is attendance at short courses specifically aimed at his/her area of responsibility and they must possess a detailed knowledge of the equipment and practices with which they are working.

A Radiation Protection Advisor is a person who has radiation safety as a major professional interest and responsibility. The duties and appropriate level of training are as described in Section 4 of this document. A clear distinction is made between a Radiation Protection Advisor and the other two categories, i.e Radiation Safety Officers and Professional Health Physicists.

The term Professional Health Physicist applies to a person who has significantly more experience and a greater depth and breadth of radiation protection knowledge than a Radiation Protection Advisor.

Under the legislation in some states there are people who have been nominated as the officer responsible for the safety of a practice and they are described as the Radiation Safety Officer. However, the term 'Radiation Safety Officer' is given a broader meaning. In some of the legislation it may include both 'Radiation Safety Officers' and 'Radiation Protection Advisors' as defined above.

The accreditation scheme described in this document is intended for Radiation Protection Advisors. Ideally, accreditation would be in both ionising and non-ionising radiation, and would cater for each of the three categories specified above. At the time of introducing this scheme, the Sponsoring Societies considered it more practical to begin with a scheme that provides accreditation in only ionising radiation and at the level of Radiation Protection Advisor.

3. Objectives of Accreditation

The objective of this accreditation scheme is to ensure that successful candidates:

3.1 understand the duties and responsibilities of a Radiation Protection Advisor,
3.2 have a broad knowledge of ionising radiation, its effects, and its relevance to mining, medicine, the public, industry, education and research,
3.3 are able to use radiation monitoring equipment to identify and quantify radiation hazards,

3.4 have a broad knowledge of the techniques for radiation protection and the ability to design and implement protection strategies,
3.5 have a broad knowledge of current legislation, the applicable standards, relevant NRL* and NHMRC* guidelines, and the IAEA Basic Safety Standards (Reference 2),
3.6 have the necessary oral and writing skills to communicate their conclusions.

4. Definition and Duties of a Radiation Protection Advisor

A Radiation Protection Advisor is defined in terms of the responsibilities that he/she must assume, and the levels of skill and professionalism that are required in order to assume these responsibilities. These responsibilities include the following (as listed in Reference 40):

4.1 supervise the radiation protection in designated radiation areas in order to minimize personal doses,
4.2 advise on safe working practices in accordance with regulations and codes of practice,
4.3 consult and liaise with the relevant regulatory authority,
4.4 ensure that all necessary licensing and registration matters are processed,
4.5 liaise with occupationally exposed persons and their superiors to ensure that the proposed work with radioactive substances or irradiating apparatus is properly planned,
4.6 arrange that areas, equipment and operations are monitored as considered necessary and upon request,
4.7 ensure that suitable personal and other monitoring devices are provided where required, kept in good working order, properly used and calibrated at least once each year,
4.8 arrange that, where measured for individuals, records of effective doses are kept for 50 years or such period as required by legislation,
4.9 arrange for any required medical services to be provided and for medical records to be kept for 50 years or such period as required by legislation,
4.10 inspect areas and installations where ionizing radiations are used or are proposed to be used and make reports and recommendations to management on radiation safety,
4.11 record and report to management and the appropriate authorities any unsafe practices or accidents,
4.12 notify station officers of the local fire brigade of the locations of any radioactive substances and radiation apparatus,

* NRL: National Radiation Laboratory, Christchurch, New Zealand.
NHMRC: National Health and Medical Research Council, Commonwealth of Australia.

4.13 prepare local rules for dealing with any foreseeable radiological accidents,
4.14 ensure that current records of all stocks and locations of radioactive substances and irradiating apparatus are maintained and kept for two years after the date of disposal,
4.15 arrange for the safe storage of radioactive substances and for the safe disposal of any radioactive waste,
4.16 provide advice to radiation workers, as well as instruction and local rules on radiation safety in an easily understandable form and on an adequate scale for occupationally exposed persons,
4.17 perform any other tasks that may be necessary to maintain a high standard of radiation safety.

5. Theory Syllabus

The prescribed texts are references 1 to 5 as listed in Appendix A.

It is assumed that candidates have completed physics and some chemistry at the first year level in a university or equivalent. Candidates are advised to acquire a knowledge of relevant anatomy and physiology and should have completed senior secondary school mathematics. Candidates must possess the following mathematical and computational skills:

5.1 Basic manipulation of equations, exponentials (Cember pp 87-92, M&H pp 13-15), logarithms, graphical techniques, counting statistics and counting precision (Cember pp396-412).

Textbooks relevant to these skills have not been included in the list of prescribed texts, although Cember (Reference 6) does cover some of this material.

Candidates are expected to have a clear understanding of the underlying principles of radiation included in the following topics:

5.2 The structure of matter (M&H chpt 1)
5.3 Radioactivity and radiation (M&H chpt 2)
5.4 Radiation units (M&H chpt 3, ICRP 60) (Note that ICRP 60 defines the units currently used. Cember's presentation is within the American context and is confusing.)
5.5 Biological effects of radiation (M&H chpt 4, ICRP 60)
5.6 Natural and man-made radiation (M&H chpt 5)
5.7 The system of radiological protection (M&H chpt 6)
5.8 Radiation detection and measurement (Cember chpt 9, M&H chpt 7)
5.9 The external radiation hazard (M&H chpt 8)
5.10 The internal radiation hazard (M&H chpt 9)

Candidates are expected to have a broad understanding of the principles of radiation practice and protection over a wide range of applications as detailed in the following:

5.11 nuclear reactor health physics (M&H chpt 10),
5.12 radioactive waste (M&H chpt 11),
5.13 x-rays and radiography (M&H chpt 12),
5.14 radiation protection in medicine (M&H chpt 13),
5.15 health physics laboratory techniques, (M&H chpt 15)
5.16 radiological emergencies, (M&H chpt 16)

Topics 5.2 to 5.16 will be examined at the level of the presentation in Martin and Sutton, though candidates are advised to broaden their understanding with supplementary reading from texts such as Cember (ref 6), Hall (ref 7), ICRP 60 and the IAEA Basic Safety Standards.

The following three topics relate to codes of practice and legislation:

5.17 legislation and regulations related to radiological protection, (Refs 5 & 2)
5.18 the organisation and administration of health physics services, (Refs 1 to 5)
5.19 duties of a Radiation Protection Advisor (Ref 40)

In studying topics 5.17 to 5.19, candidates should rely upon references 2 to 5 and 8. General questions on these topics will be included in the theory exam.

6. Assignment on Radiation Protection Program

Candidates are also required to prepare a Radiation Protection Program for a medium to large institution such as a major hospital, a university, a large mine or a mineral processing plant. In very large institutions it may be necessary to limit the program to a single department or operation in order to contain the length of the assignment. Candidates are encouraged to choose a topic that is relevant to their place of employment. The examiners will be looking for a document that can make a contribution to radiation safety either at the practical or administrative level. The program should be quite detailed and approximately 5000 words in length. Candidates may choose to include descriptions of the scenarios that have been identified (e.g. dose to fingers of staff injecting radioisotopes in a nuclear medicine department), assessments of the seriousness of the problem (i.e. dose estimation, probability that there will be a mishap), plans recommended for controlling the practice (e.g. supply syringe shields, instruct staff) and methods for ensuring that the recommendations are effective and are being followed (Reference 8). If the program is developed from a pre-existing program or prepared in association with others, then the candidate should clearly indicate what his/her contribution has been.

Preparation of the Radiation Protection Program is part of the practical section of the accreditation. Candidates will be required to defend their program during an oral examination/interview which will generally be held following the practical examination. The program should be submitted at least four weeks prior to the practical examination so that examiners can assess them prior to the interview.

7. Syllabus for Practical Work with Radiation Monitors

Candidates will be expected to have a broad understanding of the principles of operation of radiation detectors as described in Cember chpt 9, and in Martin and Sutton. It is important to understand how to select a suitable monitor for a stated purpose (e.g. monitoring for spilt radioisotopes, estimation of dose to staff from a known source). An understanding of the use of absorbers to identify the type of source is also essential.

8. Application Procedure

Applicants should obtain a current copy of this Candidates Kit from the web site of one of the Sponsoring Societies. Email addresses for these web sites are given in appendix D.

Applicants must complete the Application Form shown in Appendix B and attach the additional information as specified. Following initial inquiries with the Chairman, copies of the application should be emailed to the Registrar (copied to the Chairman and Treasurer, as indicated on the form). Any additional material should be also attached to the email, including scanned versions of original documents if unavailable in 'soft' form. If the application is accepted, and invoice for the Enrolment Fee specified in Appendix D will be sent by the Treasurer (it is possible to include the examination fee and the application fee in the same invoice).

Applicants must demonstrate that they have attained an adequate level of education or equivalent experience. Qualifications should be listed as shown in Appendix B together with the highest levels attained in physics, mathematics and chemistry. In order to verify academic achievements, candidates will be requested to present original certificates and/or correspondence for inspection during the theory examination.

Applicants with a degree or major in another discipline should prepare a brief statement addressing their ability to achieve the objectives of accreditation, i.e. 3.1 to 3.6 above. Applicants without a degree should prepare a similar statement with more emphasis on relevant experience and short courses that have been completed.

The application should include proposals for obtaining the required practical skills and the required one year of relevant experience. A statement from the Head, Chief or Director of the Department or Organisation in which the candidate is working shall be required to demonstrate the employer's willingness to provide the required relevant experience.

Some applicants will already have twelve months of relevant experience. Such applicants are advised to prepare the report described in section 11 and submit it with their application. This will enable the Board to assess it forthwith and notify the candidate of its suitability.

9. Examinations

All candidates will be required to pass a 2 hour written examination based on the prescribed Theory Syllabus. A one hour practical examination will be given based on the

practical syllabus. An oral examination/interview will also be included after the practical examination. During this interview the candidate will be required to respond to issues raised by the Examiners and to defend his/her Radiation Protection Program.

The Board reserves the right to change the content, format and rules of these examinations from time to time

The written examination contains two sections. The first consists of 40 short answer questions to be completed over one hour; all questions are compulsory. The second consists of longer questions and the candidate will be allowed a choice of questions. Appendix E contains a sample written examination with typical questions; note that the sample examination does not contain the full number of questions. Candidates will be required to achieve a pass mark of 70% in each section of the written examination. During the written examination candidates may consult references 1, 2 & 6 (Martin & Sutton, IAEA International Basic Safety Standards, Cember). Some questions will require data from the tables of the IAEA reference.

The practical examination will last for 30 minutes. Its purpose is to ensure that all candidates are familiar with the theory of operation, selection and use of radiation monitors. It is suggested that candidates bring their own portable monitor(s), but they will also be required to use other monitors. They will be asked to undertake several monitoring tasks involving the location of hidden sources and the identification of source type (α, β, γ, neutron, mixed). They will then be asked to advise on safe distances and precautions. The tasks required of candidates may be varied for those who work in specialised areas, e.g. underground mining, and candidates are advised to briefly state their area(s) of expertise in their application.

The oral examination/interview will last approximately 30 minutes. The candidate will be asked to defend his/her Radiation Protection Program. The examiners may also use this occasion to clarify any outstanding issues regarding the candidate's assessment.

Examinations will be arranged according to the availability of examiners and the number of candidates. They will be conducted by arrangement in any capital city or other centre where there are enough candidates to justify the effort.

Candidates will be notified of their results as soon as possible after each examination. Results will be stated as Pass or Fail.

10. Relevant Experience and Written Report

Candidates are required to complete one year of relevant experience working under the supervision of a suitably qualified person, preferably an Accredited Radiation Protection Advisor. During this period, candidates must spend a minimum of 60% of their time performing relevant duties. The Board will assess each candidate on the basis of:

10.1 a written report prepared by the candidate describing his/her experience, its duration and its relevance,
10.2 copies of relevant report(s) prepared by the candidate,
10.3 a written reference from a suitable referee supporting the candidate's claims in 11.1 and 11.2, and
10.4 additional evidence from the examiners after discussing the candidate's work during the oral examination.

The written report should be brief and pertinent with reports appended. If reports have multiple authors, then the covering letter should detail the contribution made by the candidate. The referee will normally be the candidate's work supervisor.

It is recommended that candidates maintain a logbook during this period detailing the tasks undertaken and including copies of any technical reports to which they have contributed. If a logbook has been kept, candidates are encouraged to discuss it with the examiners during their oral examination.

11. Notification of Results

All applications for enrolment will be acknowledged in writing or by email. At a later date, candidates will be notified of the acceptance or non-acceptance of their application.

Candidates who pass the written examination will be notified in writing by the Board that they have successfully completed the theory, but not practical, part of the accreditation.

Candidates who successfully complete the course will be awarded a certificate stating that they have gained Accreditation in Ionising Radiation Safety from the Board and the Sponsoring Societies.

The names of all successful candidates will be forwarded to the Registrar of each of the Sponsoring Societies.

Enquiries from candidates regarding their assessment should be directed to the Board. Candidates who feel aggrieved by a decision of the Board should note that there is no mechanism for appeal to the Sponsoring Societies.

In certain circumstances, a candidate may be requested to perform additional work in order to satisfy the Board that he/she has achieved the required standard.

12. Maintenance of Accreditation

The Board regards Accreditation as a Radiation Protection Advisor to be an indication that the incumbent is actively engaged in the field of radiation protection and is maintaining his/her relevant expertise and knowledge of the field.

Every third year, successful candidates will be required to apply for Maintenance of Accreditation (i.e. renewal) of their accreditation. If a candidate fails to apply for Maintenance of Accreditation within three months of the due date, then his/her accreditation will be deemed to have lapsed. When seeking Maintenance of Accreditation, candidates must submit:

12.1 a one page summary of experience gained, conferences and/or seminars attended, papers and/or reports prepared, awards gained and any other relevant material arising during the preceding three years as evidence of their continuing professional activity.
12.2 the name of at least one referee (preferably an Accredited Radiation protection Advisor) who can confirm the accuracy of the information in 12.1.
12.3 the Maintenance of Accreditation Fee shown in Appendix C.

Applications for Maintenance will be assessed by a meeting of The Board. The Board reserves the right to change the requirements for Accreditation Maintenance from time to time.

13. Powers of The Board

This Accreditation is determined and administered by the Board. The Board has over-riding authority to administer this Accreditation and reserves the right to alter any rule, condition, the syllabus, prescribed texts and/or fees from time to time.

The Board's decision is final in all matters regarding this Accreditation. There is no direct mechanism for appeal to the Sponsoring Societies.

Candidates are advised to ensure that they always have the latest edition of this Kit which is available from the web sites of the Sponsoring Societies.

14. Code of Ethics

Successful candidates are required to abide by the Codes of Ethics of the Sponsoring Societies. Accreditation may be withdrawn by the Board in cases involving serious breaches of these Codes.

15. Fees

Fees are as shown in Appendix C. Fees are not refundable.

Appendix A

Recommended Texts and Reference Material

Prescribed Texts

1. C. J. Martin and D. G.Sutton, Practical Radiation Protection in Healthcare. First Edition Oxford University Press, 2002, ISBN 0192630822.
2. International basic safety standards for protection against ionising radiation and for the safety of radiation sources. International Atomic Energy Agency Safety Series No 115, IAEA Vienna 1996. (Available from Hunter Publications, 58a Gipps St, Collingwood, Vic 3066, Australia.)
3. ICRP Publication103, 2007 Recommendations of the International Commission on Radiological Protection.valentin J., (ed.), Elsevier 2007.4. Reference 11 (NHMRC RHS No 39).
5. Radiation safety legislation from one Australian state or New Zealand.

Texts Recommended for Reference

6. H.Cember, Introduction to Radiation Protection, 3d Edition 1996,McGraw-Hill.
7. E.J.Hall, Radiobiology for the radiobiologist, 6th edition, 2006, Lippincott Williams & Wilkins.
8. Reference 40 (AS 2243.4 - 1998).
9. The Western Australian mineral sands industry: radiation protection. Department of Mines, Western Australia, 1989.
10. ISO 9000 Accreditation Guide.

ARPANSA Radiation Protection Series (RPS)

These are constantly being added to. For an up to date listing, visit http://www.arpansa.gov.au/Publications/codes/index.cfm.
These Codes and Standards are available either as printed copies (at a modest charge) or as downloads at no cost

ARPANSA Radiation Health Series (RHS) [previously: National Health and Medical Research Council Publications]
(NHMRC publications are under review by the ARPANSA Radiation Health Committee and being republished as part of the Radiation Protection Series and are available at no charge from the ARPANSA website.)

NRL Reports

37. Code of safe practice for the use of x-rays in medical diagnosis (1994), Report No NRL C5, National Radiation Laboratory, Ministry of Health, Christchurch, New Zealand, ISSN 0110 - 9316.
38. J.L.Poletti, Factors affecting patient dose in diagnostic radiology (1994), Report No NRL 1994/2, National Radiation Laboratory, Ministry of Health, Christchurch, New Zealand, ISSN 0110 - 753x.

39. Guidelines for quality assurance in radiation protection for diagnostic x-ray facilities: large x-ray facilities (1995), Report No NRL 1995/1, National Radiation Laboratory, Ministry of Health, Christchurch, New Zealand, ISSN 0110 - 753x.

Australian and New Zealand Standards

40. Safety in Laboratories Part 4 Ionising Radiations, AS 2243.4 - 1998.
41. Laboratory Design and Construction, AS/NZS 2882.1 - 1997

Appendix B

Application Form
Accreditation in Ionising Radiation Safety
within Australia and New Zealand

Please complete the following form. Obtain it in electronic (Word) format from www.arps.org.au; adjust box sizes to individual requirements. Please submit this in electronic form with the attachments requested below to the Registrar, awood@swin.edu.au with copies to david.causer@health.wa.gov.au and ray.budd@med.monash.edu.au. Candidates accepted into the Accreditation Program will be sent invoices by the Treasurer.

Candidates are urged to obtain a copy of the **Candidates Kit** from www.arps.org.au

Personal Details

1	Family Name	
2	Given Names	
3	Preferred Title	
4	Date of Birth	
5	Email Address	
6	Phone No	
7	Address for Correspondence	
8	Present Employer	
9	Present Position	
10	Professional Address	
11	Membership of Professional Societies	

Academic Record

12	Qualifications	University or Other Institution	Date Conferred
13	Highest level in physics		
14	Highest level in chemistry		
15	Highest level in mathematics		

Attachments

16. Curriculum Vitae
17. Statement of Relevant Experience (for non-graduates and for graduates in faculties other than physical sciences and engineering) (This statement should be less than one page in length.).
18. Statement describing how suitable practical experience will be obtained.
19. Statement from employer stating that suitable experience will be provided.
20. Proposed topic for Assignment on Radiation Protection Plan.
21. Statement of radiation monitoring experience to assist examiners when designing practical examination.

Appendix C

The following fees will be charged for accreditation:

	Members of ARPS, ACPSEM or AIOH	**Non-Members**
Candidate's Kit	Free download from websites of Sponsoring Societies	Free download from websites of Sponsoring Societies
Enrolment Fee	$50	$75
Theory Examination	$200	$300
Practical & Oral Examinations	$200	$300
Repeat Examination	$100	$125
Accreditation Certificate	No Charge	No charge
Maintenance of Accreditation	$130 for 3 years	$185 for 3 years

Fees are not refundable. Australian Goods & Services Tax is not currently applicable to these fees.

Appendix D

Internet Addresses for Sponsoring Societies and for Legislation

	Internet Address
ACPSEM	www.acpsem.org.au/
AIOH	www.aioh.org.au
ARPS	www.arps.org.au/
Radiation Legislation Regulations and Standards in Australia and New Zealand	www.arps.org.au/ANZ_Regs.htm

Appendix E

Sample Written Examination Paper
9:20 am Monday 28th June 1999
Bldg 72, Room 223, Green Pastures Safety Institute

This sample paper does not contain the full number of questions.
The questions shown are intended to be typical of those in the actual examination.

Candidates will require a copy of the IAEA Basic Safety Standards (Reference 2) during this examination. Candidates may also consult the texts by Martin and Sutton (Reference 1) and by Cember (Reference 6).

Time Allowed – 2 hours

Part A - Short Questions

Attempt all 40 questions. Total 40 marks for this section. Each question is worth one mark. (Most of these questions can be answered with a single word or number. Remember to include units.)

1. What is the product nucleus when $_{84}Po_{218}$ decays by α emission. (Cember has a Table of Elements and their Atomic Numbers in Appendix B.)

2. A source has an activity of 20 mCi. Convert this to MBq.

3. What is the approximate range of an α particle in tissue? (Assume that it is from a mineral sample i.e. it is not accelerator produced.)

4. Estimate the annual effective dose to a worker who spends a full working year (say 2000 h) in an area where the average effective dose rate is 2.5 μSv/h.

5. You are advising a mining company that is closing a mine. For how long should workers' dose records be kept? Quote a reference to support your recommendation.

Part B - Essay questions

Answer any six of the following nine questions. Each question is worth 10 marks. Total marks for his part is 60. (These questions can be answered in note form. Remember that if you want 10 marks, you will need to give 10 relevant facts.)

1. Define stochastic and deterministic effects. Define the terms absorbed dose, equivalent dose and effective dose; what are the units. How are these quantities used for establihing dose limits?

2. Why is there increasing concern about the effects of naturally occurring radioactive materials? Give examples from industry, mining and natural background.

   A popular, Australian, dark-coloured foodspread is rich in potassium which contains the naturallyoccurring radioactive isotope ^{40}K. A typical serve of 3g contains approximately 100 Bq of ^{40}K. Discuss how this compares with the generic action levels for foodstuffs (IAEA Basic Safety Standards, p289) What is the committed effective dose for an adult consuming a typical dose? How does it compare for a 3 year old child?

3. A 200 kBq ^{57}Co source is to used in a school. Is it necessary to licence or register it? Describe some likely accident scenarios. What advice would you give the teacher if asked about recommended precautions?