American Board of Health Physics

PREPARATION GUIDE BY AMERICAN BOARD OF HEALTH PHYSICS

PROFESSIONAL RESPONSIBILITIES
OF
HEALTH PHYSICISTS
CERTIFIED BY THE AMERICAN BOARD OF HEALTH PHYSICS

In achieving certification, the Certified Health Physicist recognizes and assumes the responsibilities due the profession of health physics. To uphold the professional integrity of health physics implied by certification, the relations of the Certified Health Physicist with other individuals and groups including clients, colleagues, governmental agencies, and the general public shall always be based upon and reflect the highest standards of professional ethics and integrity. Each certificant has a professional and ethical obligation to practice only in those areas of health physics in which he or she is competent. To maintain technical competence, the Certified Health Physicist has a commitment to remain professionally active in the field of health physics and knowledgeable of scientific, technical and regulatory developments in the field.

The American Board of Health Physics offers Comprehensive Certification in Health Physics. The certification examinations are normally given once a year at the time of the Annual Meeting of the Health Physics Society. They are held at the location of the Society's meeting and at other selected locations where the demand warrants.

Information regarding requirements for Certification, examination procedures and fees, and application materials are available on this website. Additional information is available from:

Amy Wride-Graney, Program Director
American Board of Health Physics
1313 Dolley Madison Boulevard, Suite 402
McLean, VA 22101
(703) 790-1745
FAX: (703) 790-2672
Email: aahp@BurkInc.com
Webpage: http://www.aahp-abhp.org/

Caution - The information presented about the exam specifics and other matters are believed to be correct at the time of preparation; however, the Board has revised the procedures and criteria in the past, and reserves the right to do so in the future. The candidate is advised to review the current copy of the ABHP Prospectus for the current policy.

Section 1

Message to Candidates

This guide will help you prepare for the ABHP certification examination. However, use of the Guide by itself will not be adequate preparation for the exam. Successful candidates usually start their preparation months before the test. Preparation should include a careful review of health physics fundamentals and then, with equal vigor, review of applied aspects of health physics in several of the specialty areas. The suggested study references in Section 7 will help guide you. Joining either a formal or informal study group (particularly those that continue over a period of months) can assist you by forcing a systematic review of various topics and by exposing you to the knowledge of people expert in subjects with which you are not familiar.

The Board warns against approaching the exam in a casual fashion. We find that most unsuccessful candidates did not prepare adequately. In contrast, the successful candidates have usually planned and followed a comprehensive study program. After past exams, the Board has asked candidates about some of the factors contributing to their degree of success on the exam. The Board noticed that the single most important attribute of successful candidates was the amount of time spent studying for the examination. On average, those questioned claimed to have spent an average of 300 hours in study.

Because candidates' credentials are reviewed carefully, the Board feels that all applicants declared eligible to take the examination have the potential to pass. You can avoid the disappointment of poor performance by recognizing from the start that the exam will be a rigorous test of your professional knowledge. Your grade will represent, for the most part, the thoroughness of your preparation.

Section 2

Exam Locations

The certification examinations are given one day each year. The exam is given at the site of the annual meeting of the Health Physics Society and, on the same day, at several other locations throughout the country. The exam sites for each year will be selected by the American Academy of Health Physics' Examination Site Selection Committee by February 1 of each year. All approved candidates will be sent a site selection survey form in early March listing the tentative examination sites. The candidate should indicate first and second choices of location and will be assigned to the first choice unless that site does not have enough candidates to warrant the examination being given there. All candidates will be notified of their definite exam site approximately 45 days prior to the examination date.

Exam Scheduling

Once a candidate is notified of eligibility to take an examination, the candidate is expected to appear at the next scheduled examination. Examination fees are non-refundable. Application material is only good for a two year period and must be resubmitted after two years. A candidate who is scheduled to take an exam may postpone it up to the moment before the exams are distributed. Once a candidate has received an exam, it must be submitted for scoring. Should the ABHP make policy changes that could affect a candidate's eligibility to take the exam once a candidate has been declared eligible by the admissions process, a candidate will remain eligible for the full period of initial qualification.

Re-examinations

After paying the exam fee, a candidate who fails the first examination may be admitted to the next examination without resubmitting an application if it is within two years of the application date. An application is only good for two years (two exam cycles). If a candidate passes one part of the exam, the candidate must pass the other part within a period of seven years, or must reapply and retake both parts. The candidate must notify the Board of his/her intention to retake the examination and submit the proper fee no later than January 15 of the year in which the examination is to be taken.

Section 3

The examination has two parts. Calculators may be used during the exam. No recording or transmitting devices are permitted, and all calculators with "constant" memories must be demonstrated to contain no stored constants (other than pi or *e*) or stored programs.

Part I

Part I questions are used to evaluate a candidate's knowledge of the fundamentals of health physics.

Part I is made up of 150 multiple-choice questions. The breakdown by subject matter follows the five Domains of Practice which are detailed in Section 4. The sub-areas shown for each domain give the typical subject matter covered in Part I questions. The number of Part I questions which fall in each domain is also shown in that section. Part I of the examination is constructed to test the knowledge of the fundamental aspects of health physics that is expected of any candidate meeting the qualifications for early admission to Part I. There will be questions contained in Part I that address fundamental knowledge associated with applied health physics. Academic preparation alone may not be adequate to answer these questions. However, the presence of these questions should not prevent a well-prepared candidate with no practical experience from successfully completing Part I of the Certification examination.

Each question has five possible answers from which to choose and requires thorough knowledge of the subject matter. For example, in questions that require calculations, answers other than the correct one are obtained by making some of the common calculational errors. Three hours are allowed to answer Part I (given in the morning of the examination day). Part I questions may be reused in subsequent years. As a consequence, this part of the examination is held in strict confidence and copies of past exams are not distributed. Section 8 of this Guide gives some typical Part I questions.

Part II

Part II questions are designed to test judgment, the ability to analyze and organize complex problems, and the use of practical skills at a high professional level. Candidates are given six hours in which to complete Part II (given in the afternoon of the examination day).

In the first section of the Part II exam, there are six questions on core topics of health physics. These first six questions will be graded for all candidates. (If one of these questions is left unanswered, the candidate will receive zero points for that question.) The topic areas that these questions examine are: personnel dosimetry (internal and external), shielding and activation, measurements and instrumentation, and biological effects of radiation (risk). These questions are selected so that each can be read and answered in a period of 10-15 minutes. Each question is worth 50 points and can include calculations, short essay, and/or serial-multiple-choice format.

The second section of the Part II exam contains eight problems. These problems are provided in one or a combination of the following formats: essay, short answer, calculational, serial-multiple-choice. The candidate must select any four of the eight questions provided. At least one question is provided for each of the following topical areas:

- Accelerators
- Environmental
- Fuel Cycle (mining, milling, fuel fabrication and fuel reprocessing) and waste management
- Medical
- Research and Power Reactors
- University

- General (can include emergency response, meteorology, standards and regulations, and topical subjects)
- Nonionizing

Each question from a topical area is designed such that a candidate who is experienced and capable in that area should be able to answer the question. However, all questions are kept general enough so that a person without detailed experience in an area, but who has adequately studied that area, could answer with a reasonable likelihood of success. Each question in the second section is designed to be read and answered in about 30 minutes and is worth 100 points.

Part II Subject Matter

In addition to the criteria noted above, the Part II questions are selected by subject matter to meet the percentage breakdown associated with the five Domains of Practice which are detailed in Section 4. The sub-areas shown for each domain provide the typical subject matter covered in Part II questions. Part II questions expect the candidate to show evidence of the ability to apply professional knowledge and judgement to the subject areas covered.

Section 4

Over a period of about three years in the mid-1980s, the ABHP performed an exhaustive role delineation study of what a typical health physicist does to perform his/her job. This role delineation and the detailed task analyses that followed involved approximately 100 Certified Health Physicists, and was done under the direction of the Professional Examination Service. The goal of this evaluation was to determine what subject areas, skills, and knowledge are required to perform the job of a Health Physicist, the relative importance of each subject area, and the relative seriousness involved with a lack of knowledge in each area. As a result of this study, five main categories (domains) were selected based on subject matter. Each of the five domains was further subdivided into sub-areas to account for the subjects covered in each domain. Based on the ratings done by the large group of Certified Health Physicists, the relative importance of each of the five domains was also determined and a percentage was assigned to each domain.

A survey of health physicists conducted by the ABHP in 1993, reaffirmed the results of the original role delineation study. Based on the results of this survey the relative importance of the domains remained unchanged. The ABHP again performed a survey of Health Physicists in 1999 and made minor changes.

Since the goal of any job-related examination is to test the candidate on the information required to perform their job, the ABHP selects questions for both parts of the exam so that the subject matter covered by the test questions reasonably approximates the same breakdown as the percentages associated with each of the five domains from the role delineation.

To assist you in understanding the subject matter included in each domain and in each sub-area, a listing of each domain and the sub-areas under each one, along with typical examples of the material covered in each sub-area, are provided. It must be recognized that a given question may be able to be placed into more than one domain and sub-area.

Domains and Sub-Areas

1. Measurements and Instrumentation (25% of total)

The Measurements and Instrumentation domain covers the selection and use of measuring instruments, the interpretation and reporting of the values obtained from the instruments, data quality objectives and quality control, and the calibration, maintenance and performance testing of instrumentation. Sample collection devices should be included in this domain.

Items to be included in the Measurements and Instrumentation domain:

1.1 Types of Measurements

- Criticality Monitoring and Dosimetry
- Radiation Fields, Ionizing and Nonionizing
- External Radiation Dose
- Surface Contamination
- Airborne Radioactivity Levels
- Internal Deposition including bioassay and whole body counting
- Process and Effluent Samples (Liquids, Solids, and Gases)
- Environmental Media
- Specify appropriateness of methods based on radionuclides and general workplace characteristics and operations

1.2 Selection of Instruments

- Response to different types and energies of radiation
- Limitations of instruments
- In-line instruments versus laboratory analyses
- Interpretation of instrument indications

1.3 Analytical Techniques for Sampling

- Application of statistical methods to data analysis
- Measuring removable and fixed contamination
- Frisking and scanning techniques
- Use of air sampling devices
- Testing of exhaust hoods, air flow paths, and exhaust filters
- Use of collection media for tritium, radioiodine, particulates
- Exposure pathways
- Selection of media to be sampled considering radionuclides and processes used
- Representative sampling for process, effluent, and environmental media
- Release of equipment and facilities

1.4 Measurement Methods

- Proper use of instruments to evaluate hazards based on radiation type, source characteristics, required sensitivity, and accuracy and precision
- Analyzing swipe samples
- Dosimetry processing methods
- Proper location of dosimetry
- Uptake and internal dose measurements and calculations
- Analysis of various air samples
- Calculation of DAC-hours
- Calculation of effluent concentrations and resulting dose
- Calculation of environmental media concentrations and resulting dose
- Appropriate inventory of health physics instruments used for radiation monitoring and measuring

1.5 Interpretation and Reporting of Results

- Use of models
- Account for ingrowth of decay products, decay of radionuclides, activation and radioactive decay chains, in all facets of radiation protection
- Application of counting statistics
- Evaluate background counting data to determine proper operation of radiation measurement systems
- Evaluation of radiation fields and stay-times from survey measurements
- Evaluation of whole body and organ dose from dosimetry results
- Evaluation of interferences
- Evaluation of sample results including lower limit of detection, decision level, Type I and Type II measurement errors

1.6 Quality Control and Data Quality Objectives

- Develop control charts for a counting system
- Evaluate adequacy of data management practices
- Identify data quality objectives for license termination/unconditional release survey
- Establish bias and precision performance indices

1.7 Instrument Calibration, Maintenance, and Performance Testing

- Specify appropriate standards for calibration and calibration methods
- Effects of geometry, self absorption, energy and count rate
- Calibration frequency
- Use of standards, blanks and spiked samples in analyses
- Specify performance tests for radiation monitoring and measuring instruments
- Identify improperly operating instruments used for radiation monitoring and measuring

2. Standards and Requirements (20% of total)

The Standards and Requirements domain covers the standards and guidelines of groups such as ICRP, NCRP, ANSI, ASTM, and the requirements of various regulatory agencies such as NRC, DOE, EPA, DOT, OSHA, FEMA, the Postal Service, and state agencies; these regulatory agencies also provide regulatory guidance. Guidance is also provided by industry oversight groups such as ANI and INPO.

Items to be included in the Standards and Requirements domain:

2.1 Maintenance of Licenses, Permits and Regulations

- Adequacy of information contained in license, permit, application or registration documents
- Evaluate surveys, monitoring, and records necessary to comply with license, permit or registration document requirements
- Determine need for a license

2.2 History and Development

- Evaluate historical records of operation and determine compliance with requirements in effect at that time
- Knowledge of current regulations and standards
- Measuring external radiation
- Personnel external exposures
- Contamination

- Uptakes and internal doses
- Air sampling and evaluation of air sample results
- Process and effluent monitoring and analysis of samples
- Environmental monitoring and analysis of samples
- Waste management
- Radioactive shipments, packaging and transportation
- Explain the evolution of radiation protection standards
- Identify the basis of dose level in terms of risk

2.3 Use and Application

- Calculate TEDE from a mixture of internal and external radiation sources
- Assess implementation of regulatory requirements in the field
- Assess compliance status from external dosimetry results, including deep-dose, shallow-dose, and neutron dose
- Design a safety program for
    - EMR, RF, and microwave radiation
    - IR and UV sources
    - Waste minimization and management program
- Determining Compliance by assessing adequacy of radiation control program

2.4 Types of Regulations

- Identify the types of regulations that may apply to a facility process of activity
- Explain the hierarchy of radiation protection recommendations, regulations and standards
- Identify the regulatory agency or agencies having jurisdiction over a facility, process or operation

2.5 Interpretation and Knowledge

- Identify the appropriate regulations and standards for the facility, process, or operation
- Determine compliance with basic regulations and standards by using workplace information and results of survey and monitoring

3. Hazards Analysis and Controls (20% of total)

The Hazards Analysis and Controls domain covers the identification of hazards, the use of engineered controls to eliminate or mitigate the hazard, analysis of potential failures of protective control systems and the radiological consequences of failure, types of controls and assessment of the control effectiveness.

Items to be included in the Hazards Analysis and Controls domain:

3.1 Hazard Identification

- Identify those hazards (such as physical, chemical, criticality) that could result in radiological consequences for a facility, process or operation
- Identify design basis accident for a facility, process, or operation using radioactive material or radiation producing machines
- Analyze controls for unique or first-time operations involving radioactive material or radiation producing machines
- Identify common industrial hygiene or safety problems associate with facilities using radioactive material or radiation producing machines (ozone, e.g.)

3.2 Evaluate and Assess Significance/Consequence

- Evaluate and assess the consequences of a set of hazards identified for a facility using radioactive material or radiation producing machines using fault tree or similar analysis tools
- Analyze potential for failure of protective systems and radiological consequences of failure
- Evaluate facilities, processes or operations to determine challenges to radioactive material control barriers
- Recommend appropriate mechanical protective devices such as shielding, interlocks, ventilation controls, remotely operated equipment, and devices to minimize time of exposure

3.3 Devise and Implement Controls

- Devise technical specifications, operational safety requirements, or limiting conditions for operation in response to hazards identified in an hazards analysis or safety analysis report
- Determine compliance with minimum safety requirements for a set of operational parameters and technical specifications, operational safety requirements, or limiting conditions for operation
- Implement double contingency controls for nuclear criticality safety

3.4 Types of Engineered Controls

- Specify the major components and design of air cleaning systems for particulates, radioiodines, and noble gases
- Recognize routes of exposure to radiation and radioactive material arising from a facility, process or operation
- Specify a program for the shielding requirements for permanent and temporary installation

3.5 Designs and Specifications

- Determine requirements for containment or other contamination protocols within the characteristics of a process or operation
- Evaluate shielding requirements for radiation sources
- Optimize shielding for a facility, process, or operation
- Specify decontamination methods for facilities, materials, and equipment
- Explain the basic methods used to assume nuclear criticality safety and determine compliance with criticality safety specifications
- Explain the double contingency principle as applied to nuclear criticality safety
- Specify a comprehensive inventory control program for radioactive materials
- Design a laser safety program

3.6 Selection and Evaluations

- Specify personal protective equipment and clothing (PPE) program for contamination control including criteria for selection and procedures for donning, doffing, and survey
- Specify personal protective equipment(PPE) program for control of irradiation from external sources, including lead aprons, thyroid collars, leaded gloves, and beta shielding glasses
- Select the appropriate engineered controls for radioactive surface contamination and airborne radioactivity control given the characteristics of a process or operation
- Specify the appropriate air cleaning technology given a description of the process and limitations on effluents to the environment

- Identify limitations in the use of temporary shielding (e.g., excess weight, seismic concerns, etc.)
- Evaluate the effectiveness of different decontamination methods

3.7 Use and Operations

- Determine if engineered controls are adequately implemented considering a description or diagram of a process or work location
- Assess the effectiveness of engineered controls using the results of workplace surveys and monitoring
- Identify safety requirements for the use of engineered controls (e.g., radiation monitoring of filters, traps, allowable differential pressure, drainage, etc.)
- Specify methods of source reduction (e.g., decontamination, material substitution) to minimize dose

3.8 Document and Communicate

- Prepare a hazards analysis report
- Explain the conclusions of a hazards analysis report to a non-technical audience

4. Operations and Procedures (20% of total)

The Operations and Procedures domain covers the application or incorporation of radiation protection considerations into an operating program.

Items to be included in the Operations and Procedures domain:

4.1 Standard Operating Practices and Procedures

- Specify the minimum set of health physics procedures for a given facility, process, or operation
- Specify appropriate radiological cautions into operating procedures for a facility, process or operation involving radioactive material or radiation-producing machines
- Specify radiation protection practices in the aftermath of a terrorist attach using a nuclear weapon or radioactive contamination using an improvised device
- Specify contamination control practices for a particular process or operation
- Work with other disciplines to develop appropriate processes and procedures
- Conduct periodic (announced and unannounced) audits or personnel implementing procedures to determine compliance
- Prepare an emergency response exercise scenario package for a nuclear facility or transportation scenario

4.2 Emergency Response

- Develop an emergency response plan for a facility, process or operation involving the use of involving radioactive material or radiation-producing machines
- Develop methods and procedures for recovery of lost radioactive sources
- Perform rapid assessment of potential off-site doses from an accident at a nuclear facility
- Develop appropriate protective action recommendations to off-site authorities
- Establish dose controls for emergency workers
- Specify procedures for handling of radioactively contaminated persons, including decontamination and decorporation
- Define graded responses for each type of emergency category

- Evaluate the conduct of emergency response drills and exercises
- Perform a "quick sort" procedure to evaluate personnel doses in a nuclear criticality accident

4.3 Basis for Operations and Program

Explain the basis for radiation protection program requirements considering the characteristics of the facility, operation, or process

Provide a technical justification for the frequency of surveys, monitoring, and personnel monitoring for a specified facility, operation, or process

4.4 Program Types

- Propose administrative practices to maintain personnel exposures as low as reasonably achievable using the characteristics of a facility, process, or operation
- Specify a respiratory protection program that encompasses respirator or other respiratory protective device (fresh-air hood, bubble suit, etc.) selection, fit testing, and maintenance record keeping
- Specify an access control program for a facility using radioactive material or radiation-producing machines
- Specify a radiological environmental monitoring program for a nuclear facility
- Specify a program for control of sealed radioactive sources
- Specify a radiation safety program for industrial radiography operations using sealed radioactive sources

4.5 Records

- Specify the radiation protection records required for a facility, process or operation, to demonstrate compliance with license, permit or registration requirements
- Specify the minimum content of the following types of health physics records:
    - Instrument calibration
    - Radiation/contamination survey
    - Air sample analysis
    - Process or effluent sample results
- Reconstruct estimates of releases using historical records of processes, effluents, and meteorological data
- Communication - Explain the risks and significance of radiation exposure

5. Fundamentals and Education (15% of total)

The fundamentals and education domain covers the content of training the health physicist receives and the training the health physicist prepares, reviews, and presents

5.1 Skills of the Trade - explain

- Linear no-threshold model and its application to radiation protection
- Basis for current radiation protection standards
- Effects of chronic and acute exposure to ionizing radiation
- Risk of radiation exposure to embryo/fetus
- Difference between high and low level radioactive waste and the types of controls necessary for the safe disposal of each
- Dose-response model for deterministic radiation health effects
- Health effects of exposure to lasers, UV radiation, and RF radiation
- Heritable ill-health, teratogenesis, and carcinogenesis in the contest of radiation exposure

- Principles of radiation protection for practices and interventions
- Dependence of biological effects on radiation "quality," LET, lineal energy, and microdosimetry
- How neutrons interact with tissue (e.g., thermal, fast)
- Why alpha particles differ in their effects (per unit energy deposited) from beta, gamma, and x-rays
- What is known about the natural radiation environment as a function of geography and altitude, solar cycle, and solar flares
- Technogenic additions to the radiation environment (e.g., fallout, nuclear accidents, releases from routine operations, technological enhancement, and deliberate production of radiation)
- Known effects of major radiological incidents and accidents (e.g., criticality accidernts, Three Mile Island, Chernobyl)

5.2 Types

- Determine the minimum training and education requirements for radiological workers
- Determine qualification criteria for radiological control/health physics/radiation protection technicians
- Develop a radiation training program for general employees, industrial radiography operation using sealed radioactive sources, emergency response personnel
- Perform a job-task analysis to determine job-specific training requirements

FUNDAMENTAL CHARACTERISTICS OF COMMONLY

ENCOUNTERED RADIONUCLIDES

The candidate should be familiar with fundamental characteristics of those radionuclides commonly encountered in the radiation protection field including:

H-3
C-14
F-18
P-32
S-35
Co-60Sr-90
Tc-99m
I-125 & I-131
Cs-137
Ra-226
Am-241

Fundamental characteristics include basics such as the mode of decay, principal type(s) of radiation emitted, energies of radiation emitted, and half-life.

<u>Section 5</u>

The Board believes that it is an advantage to develop a strategy for taking the certification examination. We have noted in the past that candidates have, through a number of oversights and errors, penalized themselves heavily, in some cases heavily enough to make a difference between success and failure on the examination.

While we do not believe that our suggestions, given below, are the only possible ones on examination strategy, we do believe that they are sound and that at least they should stimulate the development of a suitable plan of your own.

Part I

Part I is a multiple choice examination, lasting three hours and requiring the answers to 150 questions. Some of the answers require calculation.

1. Budget your time so that you are answering about 1/3 of the questions in each hour.
2. Begin at the beginning and go through the whole examination, answering the questions you are sure of, in order. Pass over the difficult, uncertain questions, saving them until the end. Do not lose time by getting bogged down on a few difficult questions.
3. An intelligent guess is better than no answer; there is no penalty for an incorrect answer.
4. If you are uncertain about an answer, it is probably true that your first choice is the correct answer. Do not change an answer unless you are certain that the first answer is wrong.

Part II

1. The first section of the examination consists of six core questions. All questions of this section will be graded. Each perfectly answered question is awarded 50 points for a section total of 300 points. Candidates may wish to "scan read" the entire examination, rank the questions, and start work.
2. The second section of the examination consists of eight specialty questions, but only the four selected by the candidate will be graded. The point value for each perfectly answered applied section question is 100 points for a maximum section score of 400 points.
   Some candidates may favor the greater point value of the specialty questions, the selectivity of four out of eight, and start with the applied section.
   As in the Part I examination, make a conscious effort to budget your time.
3. Before beginning to answer a question, read it again carefully so that you can be certain you are answering the question that is asked.
4. Think carefully about numerical constants and assumptions that you use. Try to be sure that they are accurate and reasonable. If you are unable to remember a constant or equation, make a reasonable estimate and clearly state this as an assumption.
5. Do your best to demonstrate a professional approach to the problems.
6. Organize your answer in a logical outline form to use as a check list to assure efficient and complete subject treatment. A concise, neat, well-organized answer is much more impressive than a rambling ten page dissertation. Try to scale your answer to the length of the sample questions.
7. Reread the question after completing it to be sure you have answered all the portions of the question and have provided all the information requested.
8. Remember, the onus is on you to prove your mastery of the material through your answer to the grader.

Additionally, the following test-taking tips were compiled for Part II Candidates based on graders' collective experience grading many Part II exams. These tips are provided to help you avoid problems that have adversely impacted previous candidates.

- Read questions thoroughly. Determine what the question is asking and what information is necessary to answer that question.
- Respond in an organized, logical manner. Develop a clear and logical plan for a response, especially for calculations. Lay out a plan or sequence to get partial credit.

- Work step by step according to your plan. Number steps or sub-steps to keep your response orderly.
- Use at least one line per step, more if necessary. Do not cram information in a small space.
- Use as many sheets of paper as necessary.
- Do not erase; line out completely. Lining out is neater and takes less time. Incomplete erasures show up on copies and may be confusing and misleading to the graders.
- Write clearly. Use your best penmanship. Some responses are difficult to interpret and grade because they are hard to read. Don't make the grader have to work too hard to figure out what you wrote.
- Use radiological terms when possible. Sometimes a single phrase of a few key words is all that is needed to convey a response, such as high LET, low specific activity, GI syndrome, etc.
- Reference standards or regulations to explain and clarify your response if necessary.
- Use the correct units in your calculations.
- When using units, clearly state which numerical value is associated with that unit.
- Stick with technical responses and data. Do not add any editorial or personal comments.
- Use the equations and formulas provided in the Useful Equations, Formulas, and Constants Sheet when applicable.

For general test taking strategies, check www.testtakingtips.com.

Section 6

A candidate must pass both parts of the certification examination to be considered for certification. A candidate that takes both parts of the exam on the same day and passes Part II but fails Part I must pass Part I before being eligible for certification.

Part I Passing Point Criteria

To pass Part I, the candidate must answer at least 95 questions correctly.

Part II Passing Criteria

To pass Part II, a candidate must achieve 67.0 percent or better on Part II (469 points out of 700). Starting with candidates sitting for the 2014 Part II exam, candidates who fail to receive a minimum of 300 points weighted (out of 700 available) will have to wait one year before being allowed to sit again for the Part II exam. This requirement does not apply to candidates in their sixth and final year of eligibility since passing the Part I exam.

Availability of Performance Information

Candidates will receive their performance information on any part that they failed.

Section 7

The following bibliography is intended to provide the candidate with reference material related to the general topics covered in the exam. The Board does not mean to imply that study of these references, only, will ensure successful performance on the examination. This listing is by no means complete, and the candidate may need to consult additional reports, journals, and text books for information not provided in the references below. Candidates may also want to check for the most recent edition of the references below as these may provide more up-to-date material.

At the same time, the Board does not want to imply that study of all of these references is necessary to successfully complete the examination. The list is provided as a guide to the type of material that should be studied.

1.National Council on Radiation Protection and Measurements Reports

The NCRP publishes several reports each year dealing with radiation safety and the basic science supporting recommendations for controls. Many of these reports are valuable resources for studying for the certification examination. While a lengthy list of about one hundred reports may be found on the NCRP website (http://www.ncrp.com/), the candidate would not be well served by trying to read all of these reports. Some of the more valuable reports are listed below (report number, title, and year published). Note that this list is not to be considered all-encompassing. Some candidates may find other reports useful, or find that some of these reports do not add to the level of understanding to answer exam questions. The reports were divided into the following general categories: basic science, physics, radiation protection, emergency planning, nonionizing radiation, and environmental studies.

Basic science – including radiation biology and epidemiology

136 Evaluation of the Linear-Nonthreshold Dose-Response Model for Ionizing Radiation (2001)
130 Biological Effects and Exposure Limits for "Hot Particles" (1999)
128 Radionuclide Exposure of the Embryo/Fetus (1998)
121 Principles and Application of Collective Dose in Radiation Protection (1995)
115 Risk Estimates for Radiation Protection (1993)
104 The Relative Biological Effectiveness of Radiations of Different Quality (1990)
101 Exposure of the U.S. Population from Occupational Radiation (1989)
100 Exposure of the U.S. Population from Diagnostic Medical Radiation (1989)
92 Public Radiation Exposure from Nuclear Power Generation in the United States (1988)
82 SI Units in Radiation Protection and Measurements (1985)

Physics – including radiation detection instrumentation

97 Measurement of Radon and Radon Daughters in Air (1988)
57 Instrumentation and Monitoring Methods for Radiation Protection (1978)

Radiation protection – for the fields of medicine, dentistry, nuclear power, space applications, educational institutions, radiography, etc. The reports review development, recordkeeping, procedures, and other elements of specific programs.

145 Radiation Protection in Dentistry (2003)
144 Radiation Protection for Particle Accelerator Facilities (2003)
127 Operational Radiation Safety Program (1998)
120 Dose Control at Nuclear Power Plants (1994)
117 Research Needs for Radiation Protection (1993)
116 Limitation to Exposure to Ionizing Radiation (1993)
105 Radiation Protection for Medical and Allied Health Personnel (1989)
88 Radiation Alarms and Access Control Systems (1987)

Emergency planning – for radiation exposures, radioactivity releases

138 Management of Terrorist Events Involving Radioactive Material (2001)
65 Management of Persons Accidentally Contaminated with Radionuclides (1980)

Nonionizing Radiation

119 A Practical Guide to the Determination of Human Exposure to Radiofrequency Fields (1993)
86 Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields (1986)
74 Biological Effects of Ultrasound: Mechanisms and Clinical Implications (1983)

Environmental studies – radioecology, pathway analysis, radiation exposures in the environment

103 Control of Radon in Houses (1989)
94 Exposure of the Population in the United States and Canada from Natural Background Radiation (1988)
93 Ionizing Radiation Exposure of the Population of the United States (1987)
62 Tritium in the Environment (1979)
50 Environmental Radiation Measurements (1976)

It is recommended that a candidate carefully consider the areas in which he/she feels the need for significant additional basic study. Then obtain the listing of publications from the NCRP website and use those reports as study references. Most libraries associated with a university health physics program will have the NCRP publications available for review. This avoids considerable time and the expense of having the candidate order the reports.

Listing and publications also available from:
NCRP Publications
7910 Woodmont Avenue
Bethesda, MD 20814

2.International Commission on Radiation Protection Publications -
Listing and publications available from:
Elsevier Science, Inc
660 White Plains Road
Tarrytown, NY 10591-5153
Or
http://irpa.sfrp.asso.fr/ or http://www.elsevier.com/

3.International Commission on Radiation Units and Measurements Reports.
Listing and reports available from:
ICRU Publications http://www.elsevierhealth.com/journals/icrp/
7910 Woodmont Avenue
Bethesda, MD 20814
Or
http://www.icrp.org

4.ANSI Standards.
Listing and Standards available from:
American National Standards Institute
11 West 42nd Street
New York, NY 10036
212-642-4900

5.Chart of the Nuclides
The 15th edition (1996) of the General Electric Chart of the Nuclides is available as a booklet or wall chart and is available from:
General Electric
Chart of the Nuclides
c/o GE Nuclear Energy
175 Curtner Avenue M/C 948
San Jose, CA 95125-1088
1-800-668-7379
E-mail: nuclides@sjcpo2.ne.ge.com,
Or http://www.iss.external.lmco.com/kapl/chart.htm

6.Book References:

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UNIPUB, Inc.
4611-F Assembly Drive
Lanham, MD 20706-4391

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Section 8

1. Disks or foils of copper, cadmium, or aluminum are often incorporated into thermoluminescent dosimeters (TLDs) in order to:

1. measure neutrons via the n-alpha reaction.
2. facilitate the annealing process.
3. filter out high-energy background radiation.
4. filter out low-energy background radiation.
5. provide information about the photon energy spectrum.

2. A mono-energetic photon beam is measured to have an exposure rate of 100 mR hr-1 at 1 meter.

An absorber of 0.2 m thickness (μ = 6.93 m-1) is placed in the beam. What is the shielded exposure rate at 5 meters from this source?

1. 1 mR hr-1
2. 4 mR hr-1
3. 5 mR hr-1
4. 20 mR hr-1
5. 25 mR hr-1

3. According to ANSI Z136.1 "For the Safe Use of Lasers", what Class applies to a laser which emits light in the visible portion of the spectrum such that eye protection is normally afforded by the aversion response including the blink reflex?

1. Class 1.
2. Class 2.
3. Class 3R.
4. Class 3B.
5. Class 4.

4. The maximum dose rate permitted at any point on the external surface of a package of radioactive material offered for transport in other than a sole-use transport vehicle is:

1. 2 mrem/hr.
2. 5 mrem/hr.
3. 25 mrem/hr.
4. 50 mrem/hr.
5. 200 mrem/hr.

5. Right-angle scattered x-ray radiation exposure measured one meter from the beam of a fluoroscope will be:

1. about 0.01% of the incident beam at the scatterer.
2. about 0.1% of the incident beam at the scatterer.
3. about 1% of the incident beam at the scatterer.
4. about 10% of the incident beam at the scatterer.
5. of little significance and can be ignored for all practical purposes.

6. Most of the documented harmful biological effects in humans from microwave radiation are attributed to hyperthermia. These include damage mainly to the eyes and:

1. muscle.
2. testicles.
3. cardiovascular system.
4. nervous system.
5. skeleton.

7. If an airborne release occurs because of a loss of coolant accident at a light water power reactor in which fuel damage but no core melt occurs, the first radioisotope of concern through the *food chain* is:

1 90Sr.
2. 137Cs.
3. 3H.
4. 135Xe.
5. 131I.

8. When air is sampled by being pulled through a filter paper, the radioactivity at equilibrium on the filter paper due to naturally occurring radon daughters is:

1. proportional to the flow rate of the sampler.
2. dependent only on the total volume of air sampled.
3. dependent on the period of time required for radioactive equilibrium on the filter paper to be established.
4. dependent on the volume of air sampled after radioactive equilibrium on the filter paper has been established.
5. independent of the flow rate of the sampler.

9. The *biologically most significant type* of interaction of thermal neutrons with atoms in tissue is:

1. ionization.
2. elastic scattering.
3. inelastic scattering.
4. hydrolization.
5. capture.

10. All of the following are common causes of significant radiation exposure in the use of x-ray diffraction equipment *except*:

1. alteration or removal of shielding in order to perform a specialized analysis.
2. visual alignment of the beam without using a leaded glass shield.
3. placement of fingers in the primary beam while changing samples.
4. failure to incorporate shielding in the walls of the room in which the unit is housed.
5. failure to realize that x-ray beams are emitted from exit ports other than the one of immediate concern.

11. To avoid criticality when processing waste fissionable material, the size and shape of the container and the concentration are most important for:

1. a liquid slurry.
2. small, dry solid pieces.
3. dry powder.
4. large solid pieces.
5. an alloy of less dense metals.

12. A solution contaminated with plutonium has spilled on the ground near a facility. There are no other radioactive materials in the solution. Which one of the following is the most appropriate primary survey instrument to assess the extent of the contamination?

1. Portable thin NaI(Tl) scintillator (FIDLER).
2. Portable high purity Ge spectrometer.
3. End-window GM survey meter.
4. Air-proportional alpha survey meter.
5. Gas-proportional alpha survey meter.

13. A certain radioisotope has a biological half-life in the human body which is three times as long as its radiological half-life. What is the effective half-life?

1. three-fourths of its radiological half-life.
2. four-thirds of its radiological half-life.
3. four times its radiological half-life.
4. one-third of its biological half-life.
5. its biological half-life.

14. When uranium hexafluoride is released to the atmosphere, hydrolysis results in the production of hydrofluoric acid and uranyl fluoride. The primary health hazard associated with such a release is:

1. chemical toxicity of uranium.
2. radiotoxicity of uranium.
3. chemical toxicity of UF6.
4. chemical toxicity of HF.
5. chemical toxicity of F2.

15. In branching decay, a substance may decay by two or more modes. If there were only two modes of decay, the formula for the half-life would be:

1. T1/2 = (λ1 + λ2)/*ln*2
2. T1/2 = (T1/2)1 + (T1/2)2
3. T1/2 = 1/ λ 1 + 1/ λ 2
4. T1/2 = *ln*2/ λ 1 + *ln*2/ λ 2
5. T1/2 = *ln*2/(λ 1 + λ 2)

16. An investigator has received some 95Zr (half-life = 65 days) for use in a long-term study. He finds the zirconium to be contaminated with 60Co (half-life = 5.24 years) such that the ratio of 60Co activity to the 95Zr activity is 0.012. After the initial assay, the activities of the two emitters will become equal in:

1. 280 days.
2. 290 days.
3. 340 days.
4. 360 days.
5. 430 days.

17. The count rate for an effluent particulate filter is measured in a proportional counter. Which of the following system calibration parameters is most crucial in converting the result to an activity for use in airborne concentration assessment?

1. FWHM resolution.
2. Fano factor.
3. Absolute efficiency.
4. Intrinsic efficiency.
5. Signal-to-noise ratio.

18. For a narrow beam of photons, the relaxation length is that thickness of absorber that will result in a reduction of ____ in the initial beam intensity.

1. 1/10.
2. 1/2.
3. 1/*log* 2.
4. 1/*ln* 2.
5. 1/e.

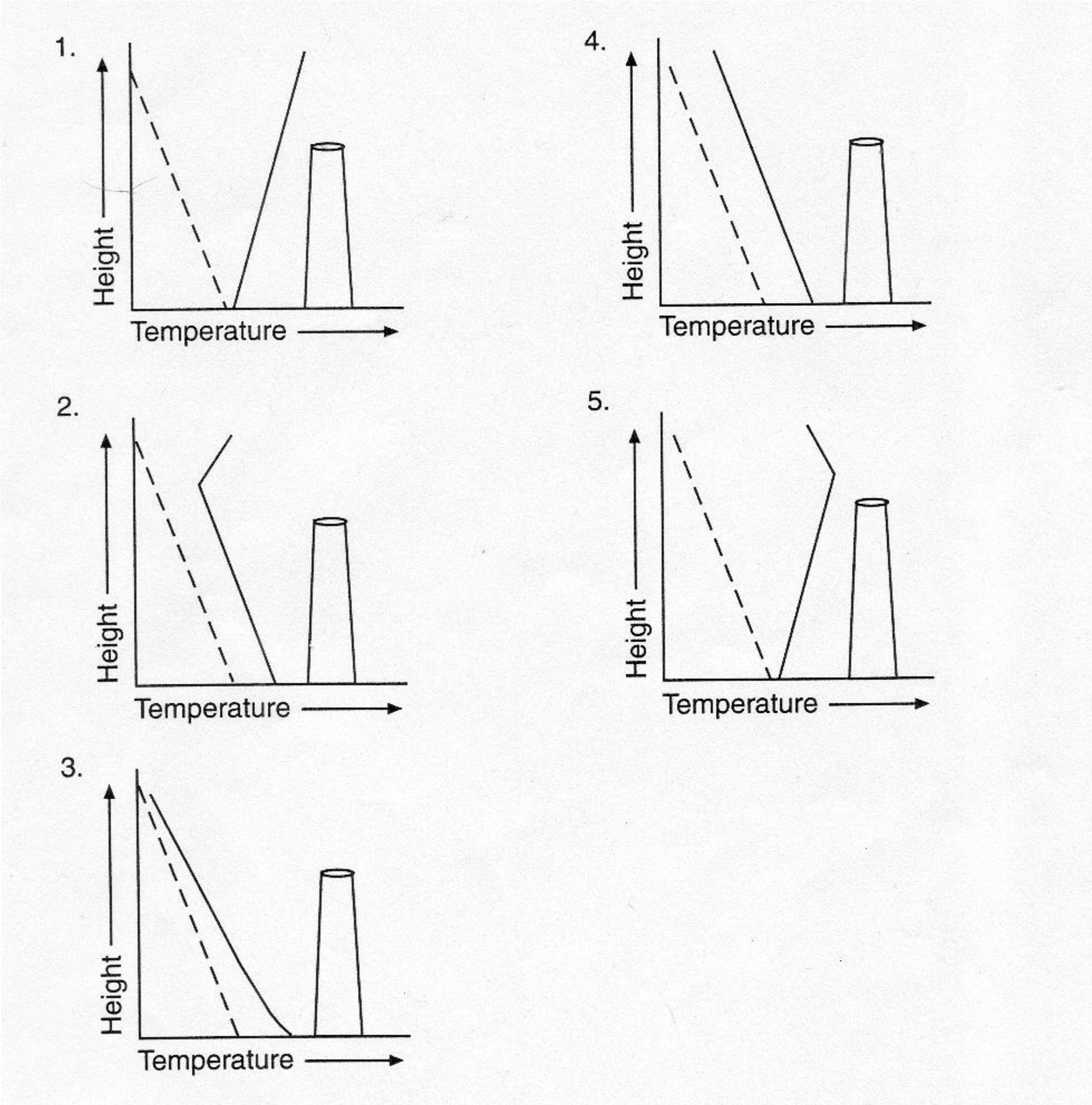
19. In a satisfactory "air-walled" ionization chamber the ionization per cubic centimeter would be:

1. inversely proportional to the density of the gas in the chamber.
2. inversely proportional to the gamma-ray energy absorbed per cubic centimeter of wall material.
3. independent of the volume of the chamber.
4. independent of the density of the gas in the chamber.
5. directly proportional to the linear stopping power of the walls for electrons.

20. An *ionization chamber* was exposed to 10-2 C kg-1 of x-rays at a rate of 10-4 C kg-1 s-1. The same chamber was then exposed to 10-2 C kg-1 at the rate of 10-2 C kg-1 s-1. If the second exposure reading was less than the first reading, the most likely cause is:

1. recombination.
2. leakage.
3. resolving time.
4. a decrease of energy absorption.
5. an increase in absorption coefficients.

21. Which diagram of atmospheric conditions would result in lofting following release from the indicated stack? Note: Dashed lines represents the adiabatic lapse rate and the solid line represents current conditions.



22. An air sample is counted for 10,000 counts. What is the relative probable error in percent?

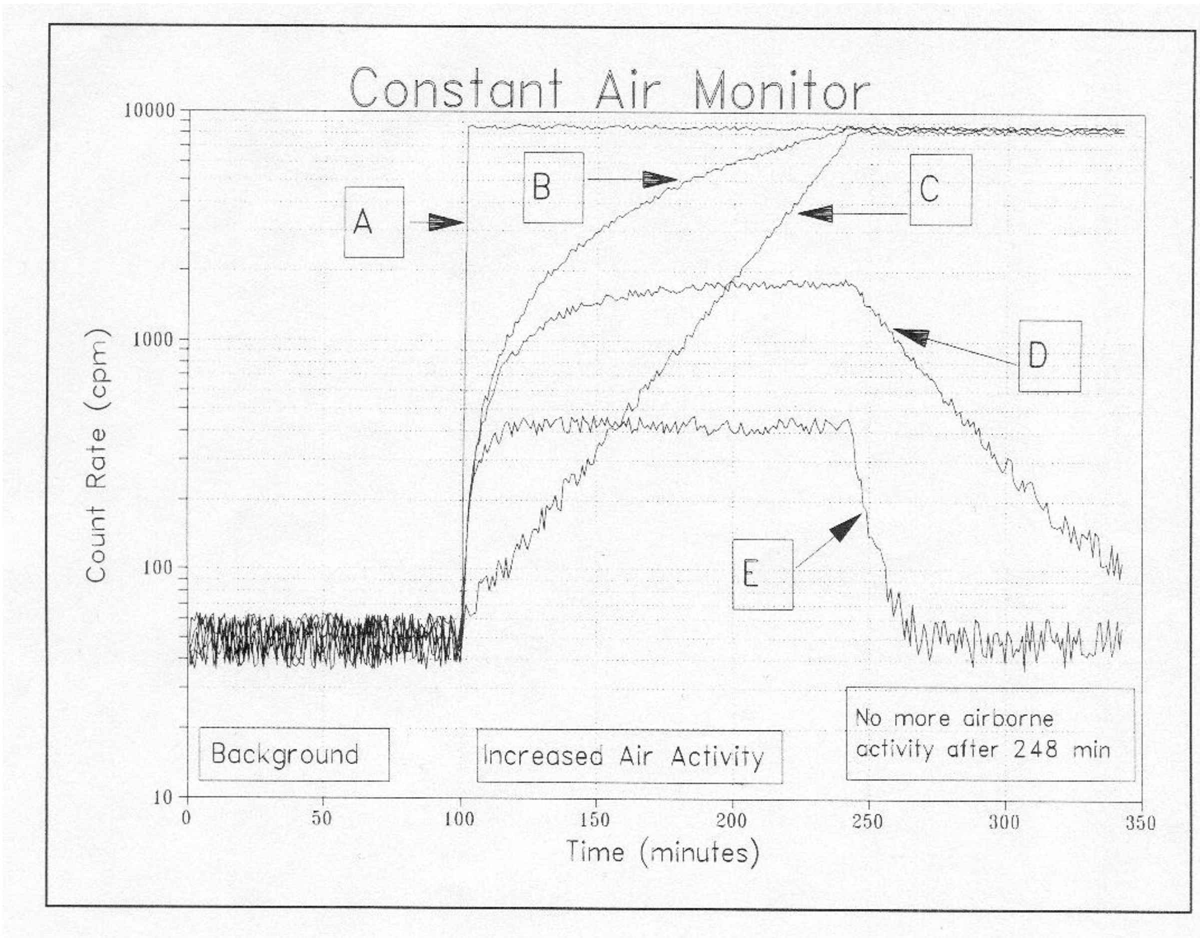
1. 0.1
2. 1
3. 10
4. 100
5. 1,000

23. A school district draws its drinking water from an aquifer that contains quantities of Ra-226 requiring pre-treatment. The water is passed through an ion-exchange resin prior to distribution. Which of the following best defines the Ra-226 loaded resin?

1. Source Material
2. UNORM
3. NORM

4. TENORM
5. Byproduct Material

24. The figure shows five traces labeled A through E for a fixed filter Constant Air Monitor. Each represents a physically possible combination of a fixed or varying concentration of a single nuclide collected on the filter, with negligible self-absorption. The CAM trace starts at a background level, increases as the airborne activity is collected, and then continues after all activity in the sampled air is gone.



Which trace most likely represents a nuclide with a half-life of about 20 minutes?

1. Curve A.
2. Curve B.
3. Curve C.
4. Curve D.
5. Curve E.

25. What is the appropriate location for a declared pregnant fluoroscopist to wear an assigned fetal badge?

1. Over the lead apron at the collar
2. Under the lead apron at the chest
3. Over the lead apron on the upper left arm
4. Under the lead apron at the abdomen

5. Declared pregnant workers are restricted from performing fluoroscopy and would not be issued a fetal badge.

Question Number	Correct Answer
1	5
2	1
3	2
4	5
5	2
6	2
7	5
8	1
9	5
10	4
11	1
12	1
13	1
14	4
15	5
16	5
17	3
18	5
19	3
20	1
21	5
22	2
23	4
24	4
25	4

Section 9

Prior to 2003, the ABHP allowed candidates to retain their copies of the Part II exam. Starting with the 2003 exam, this practice was discontinued to facilitate reuse of exam questions.

All exams are provided in pdf format.

Since 1999, Part II candidates have been provided with a formula/equation sheet. The link provided is to the current version of the document.

2002 Exam (152K)
2001 Exam (90K)
2000 Exam (113K)
1999 Exam (203K)
1998 Exam (90K)
1997 Exam (6.4 M)
1996 Exam (2.21 M)
1995 Exam (98K)

1994 Exam (4.46 M)
1993 Exam (3.63 M)
1988 Exam (1.16 M)
1987 Exam (831K)
1986 Exam (472K)
1985 Exam (422K)
and for the truly curious...
1961 Exam (712K)

Sample solutions for 1996-2001 are available here

Section 10

EXAM SOLUTIONS

Kenneth Skrable, George Chabot, Clayton French, and K.A.L., Inc.

A Few Words from the American Academy of Health Physics:

The exam solutions and answers presented on these web pages are the sole product of Kenneth Skrable, George Chabot, Clayton French, and K.A.L., Inc. While these solutions are very likely very good ones, having been prepared by such knowledgable and dedicated educators, they are NOT the "official" solutions prepared by the American Board of Health Physics. Nor are they the ones used in the grading of candidates' examinations. The Board does not assert that these solutions are correct or the best ones possible.

SOLUTIONS AND ANSWERS TO ABHP EXAMS

Methodology in Obtaining Solutions to the ABHP Exam

Equations containing either algebraic symbols or their given numerical values and corresponding units are used to obtain numerical answers for quantities asked in a question on an American Board of Health Physics (ABHP) exam. Symbols representing quantities in an equation are defined either in our list of general given information after the stated premise to a question or within the solution to each part of a question. The algebraic symbol for a quantity is understood to have a numerical value corresponding to certain specified units. When symbols for quantities are contained in the ABHP question itself, these same symbols are used in the equations giving the solution(s). Any necessary change in a given symbol or in its given numerical value and units will be indicated in our solution. If no changes are indicated in our solutions, then the given numerical values and specified units are understood to apply to the symbols stated in the question. To obtain numerical solutions to the various parts of a question, bolded numerical values and their corresponding units for given or calculated quantities are understood to be used in place of the algebraic symbols representing those quantities in the equations. This procedure is followed to make clear our solutions and answers, which are identified by a * to the left of the text or equation containing a numerical answer, which also is bolded along with its corresponding units. Except for answers read from given figures, other numerical answers are shown to three significant digits regardless of the number of significant digits of input quantities used to calculate an answer. Sometimes only the numerical values and their corresponding units for given quantities are shown in an equation giving the solution for another quantity.

To make clear our solutions, more detail and information are provided in our solutions than needed or recommended. Some quantities stated for an ABHP question sometimes are not used in the solutions for that question. Such extraneous or irrelevant quantities may or may not be listed in our summary of the given information to a question, but their algebraic symbols and their numerical values will not be bolded if listed. When given extraneous or irrelevant quantities could be used in a solution, they will be listed, and an explanation sometimes will be given in comments on any confusion that might arise from the use of such quantities. Sometimes a particular question cannot be solved with the information explicitly given, which may require the candidate to make certain assumptions. Solutions to such questions will be provided, however, along with the required assumptions. Comments provided in our solutions are intended to provide guidance to candidates in answering a particular question, and sometimes the information in a comment is needed for a solution. We encourage readers of our solutions to this exam to contact us when they find an error in our solutions or comments.

CAUTION: Equations presented in these solutions frequently involve some very small symbols. Please be sure to make free use of Adobe Acrobat's "+" (zoom-in) button to avoid errors. Likewise, printers having an HONEST resolution of less than 300 dpi may fail to provide adequate rendition. Symbols especially vulnerable to such errors include the "right arrow" when used as part of a "limit as x approaches 0" and the congruence symbol.--Webmaster

2001 Exam (1.39M)
2000 Exam (563K)
1999 Exam (664K)
1998 Exam (171K)
1997 Exam (265K)
1996 Exam (187K)