Introduction To RADIOLOGICAL MONITORING

FOR ACCIDENTS OR INCIDENTS

RADIOLOGICAL MAINTENANCE PROGRAM, CAMP DODGE, IOWA

MAY 1974

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INTRODUCTION TO RADIOLOGICAL MONITORING FOR PEACETIME ACCIDENTS OR INCIDENTS

HOME STUDY COURSE

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GENERAL INFORMATION

In the unlikely event of an accident at a fixed nuclear power station or in an accident in the use of, or in the transportation of radioactive material, some radioactive material could be released to the atmosphere. In order to evaluate the hazards to people, livestock, and growing plants, a system for gathering and analyzing information, and eliminating danger areas must be established.

One of the most significant parts of this system is the use of Civil Defense radiation detection equipment by police, fire, and other emergency workers to detect the presence of radioactive material. Police, fire, and other emergency workers must be well trained to be able to protect themselves and the citizens in their communities from the hazards of radioactive material.

To become fully qualified, it will be necessary to complete this home study course and complete additional practical courses in the use of the equipment. This practical course will be conducted throughout the State. Contact your local Civil Defense director to arrange for a course to be conducted in your area.

This course consists of 3 units of programmed instruction and a final examination.

PEACETIME USES OF NUCLEAR ENERGY

Since the spectacular flight of the Enola Gay brought an abrupt end to World War II, most Americans--indeed, most of the earth's inhabitants--have been acutely aware of the spectre of the mushroom cloud. It's true, of course, that nuclear energy forms the basis of the most devastating weaponry known to man. But it's equally true that we have already discovered hundreds of so-called "peaceful" uses of nuclear energy, and the possibilities are limited only by our imaginations and devotion to the discovery of additional applications of this tremendous force.

As then-President Dwight D. Eisenhower stated in a message to the Atomic Exposition in Rome in 1954: "We have only recently passed the midpoint of the 20th Century, yet, I am convinced that one day history will record as the most far-reaching physical accomplishment of all the century, or even twenty centuries, the discoveries which in recent years unlocked for the use of mankind the boundless energy of the atom. From among the numberless generations which have peopled this planet, destiny has now called upon those living to reach decisions on the use of nuclear energy that will govern a major measure of the future of mankind."

Let's take a closer look, now, at how nuclear energy is created and controlled for peacetime purposes. Then we'll discuss some of the uses to which this energy has been put.

TYPES OF NUCLEAR REACTIONS

The nucleus of the atom isn't a simple structure. Instead, it's a complex, dynamic system that can be modified to form other structures --an almost infinite number of them, in fact.

The atomic nucleus tries to maintain stability, much like water seeks to remain level. If the nucleus of the atom becomes unstable for some reason, it will emit one or more particles until it regains stability. These emissions are often made with much greater energy than the force that caused the atom to become unstable to begin with, and this can cause the "chain reaction" of energy we've heard so much about.

A stable atomic nucleus can be made unstable by bombardment with fast-moving projectiles, such as protons, neutrons, alpha particles, electrons, and X-rays.

NUCLEAR FISSION

The atoms of certain materials, when bombarded with energy projectiles such as the protons, neutrons, alpha particles, electrons, X-rays, etc., mentioned above, actually split into two new atoms. This process is called fission, and the new elements thus formed are known as fission products. Nuclear fission--the production of fission products--is accompanied by the release of tremendous amounts of energy, which we have learned to harness and put to work.

By placing such fissionable materials as uranium-235, plutonium-239, or thorium-233 in a chamber known as a nuclear reactor, we can bombard the nuclei of their atoms with projectiles--"bullets" of energy, like protons or neutrons--in a controlled manner. This causes the fissionable atoms to split, releasing energy as described, which we can then direct to our own uses. The fission products are highly radioactive and have varying half-lives (they retain radioactivity for varying periods of time), and we've been able to use them in medicine, agriculture, and industry, as well as in weaponry. In addition, the release of energy in a nuclear reactor results in the production of a great deal of heat, which we've also learned to channel for our own uses.

ISOTOPE USES

Radioactive elements which characteristically emit radiation are called isotopes. We've learned to use these isotopes in several of the following ways:

1. Diagnosis of brain tumors.

2. Diagnosis of thyroid gland disturbances.

3. Treatment of cancer.

4. Plant metabolism.

5. Diet additives.

6. Trace circulatory systems for leaks.

7. Follow batches of oil through pipelines.

8. Lubrication studies.

9. Radiographs of casting.

10. Thickness gauging.

11. Density gauging.

12. Sterilization of food.

As you can see from the above, we have already devised many, many peaceful uses of nuclear energy. But we have only scratched the surface of possible uses of this tremendous force. Work is progressing rapidly in many areas. Research in this field continues.

GLOSSARY OF TERMS

Alpha particle: A positively charged particle emitted spontaneously from the nuclei of some radioactive atom. It is physically identical with the nucleus of a helium atom, having two protons and two neutrons.

Atom: The smallest particle of an element that still retains the characteristics of that element.

Background radiation: Nuclear radiation arising from surroundings to which an individual is always exposed. Some of the sources are uranium and thorium present in rocks, [redacted].

Beta particles: A negatively charged particle emitted spontaneously from the nuclei of some radioactive atoms. It is physically identical to an electron.

Critical: Capable of sustaining at a constant level a chain reaction.

Curie: A unit of radioactivity. That quantity of radioactive nuclide disintegrating at the rate of 37 billion disintegrations per second. Several fractions of the curie are in common use:

- Millicurie: one thousandth of a curie.
- Microcurie: one millionth of a curie.

Dose: The amount of nuclear radiation delivered to the body. The term dose is often used in the sense of exposure dose, expressed in roentgens.

Dose rate: The amount of nuclear radiation to which an individual would be exposed per unit of time. It is usually expressed in roentgens per hour (R/hr) or milliroentgens per hour (mR/hr).

Dosimeter: An instrument for measuring total exposure to nuclear radiation.

Electron: A particle of very small mass carrying a negative charge.

Fission: The process whereby the nucleus of a particular heavy atom splits into (generally) two nuclei of lighter atoms with the release of substantial amounts of energy.

Gamma rays: Electromagnetic radiation of high energy originating within the nucleus of an atom. Physically gamma rays are identical to high energy rays.

Geiger counters: An electrical device used to detect or measure relatively low levels of nuclear radiation. The CD V-700 is an example of a geiger counter.

Half life: The time required for the activity of a given radioactive isotope to decrease to one half of its initial value. Each radioactive isotope has a different half life.

Half thickness: The thickness of a given material that will absorb half the gamma radiation incident upon it.

Isotope: Forms of the same element having identical chemical properties but differing in the number of neutrons in their nucleus.

Neutron: A neutral particle with no electrical charge present in the nucleus of all atoms except ordinary hydrogen.

Nucleus: The small, central, positively charged region of an atom.

Nuclear reactor: An apparatus in which nuclear fission may be sustained in a self-supporting chain reaction.

Pig: A container (usually lead) used to transport and store radioactive materials.

Protons: A positive particle present in the nucleus of all atoms.

Radioactivity: The spontaneous disintegrations of all unstable atoms.

Roentgen: A unit of exposure dose of gamma or X-rays. Abbr: R.
Milliroentgen: One thousandth of a roentgen. Abbr: mR.

VIII.

HOW TO USE THIS BOOK

This course is presented in a special format known as programmed instruction, a learning technique based on the concept that you learn better when you take an active part in studying. Since this is a home study course, you don't have the benefit of a personal instructor. Instead, you should regard the text itself as your instructor and follow all the instructions you find in it.

In programmed instruction, information is presented in small pieces called "frames." In a frame, you're given information, then asked to make a response based on what you've been told. You may be asked, for example, to fill in the blank, check a correct answer, or label a drawing. The correct answer is then provided so that you can check on your progress through the material.

The answers will appear to the right of the frames, as shown below. Cover the correct answers with a blank piece of paper, such as a 3 x 5 card or a mask torn from the next page of this book, until after you've answered the frame as you think you should. Then move the paper mask down and check your answer. Heavy lines between frames tell you how far to move your mask to reveal only one answer at a time. Here are a couple of sample frames. (If you have not yet obtained a mask, tear a strip of paper from the next page and cover the answers below.)

FRAME	ANSWER
FRAME 1 A person who collects radiological data and reports it performs a function called monitoring. It follows that this person is called a radiological ________________.	monitor
FRAME 2 When a monitor has obtained radiological data, he should (CHECK THE CORRECT ANSWER): ___A. keep it hidden--it's confidential. ___B. report it as directed by his community's standing operating procedure.	B is correct.

Now, you may be thinking that it's awfully easy to "cheat" by looking at the answer before writing your own. It is. But you won't learn as well, or as easily, if you do so.

After you complete each unit you will find a Unit Test. This, also, is handled on the "honor system." The correct answers for all unit tests are found on page xxx in the back of the book. If you find some of your answers are incorrect you are to review the material until you understand it before beginning the next unit.

UNIT I

BASIC RADIATION AND EFFECTS

UNIT ONE

BASIC RADIATION AND EFFECTS

OVERVIEW

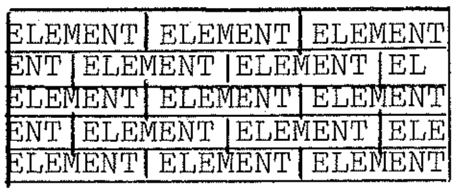
In this unit you will learn the different types of radiation and their effects on the human body.

Much of what you're learning on radiation effects is presented in general guidelines only. For example, no two people necessarily react to an identical dose of radiation in exactly the same way. Still, you may need guidance in determining hazards before health physicists or radioactive assistance teams arrive in your community.

Ready? Go to Frame 1 and begin this unit.

ELEMENTS AND ATOMS

1. Let's discuss a few terms you'll run across in dealing with radiation. The first of these is "element". Elements are sometimes referred to as the "fundamental building blocks of nature".



Such things as hydrogen, nitrogen, iron and tin are _______________.

elements

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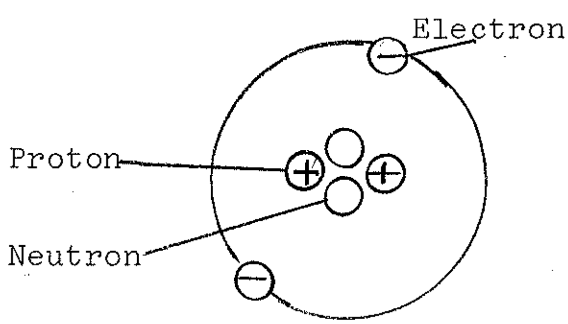
2. Suppose you could take one of these elements--iron, for instance--and break it into tiny pieces. The tiniest piece you could break it into and still have a chunk of iron is called an atom of iron. Atoms



usually have all of the parts shown here. Neutrons are neutral in electrical charge, but, as indicated by the signs:

A. electrons have a _______________. electrical charge.
b. protons have a _______________. electrical charge.

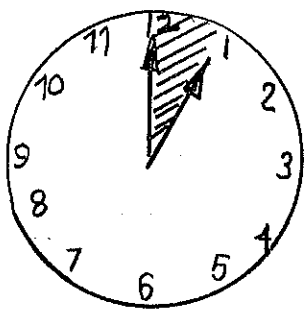
A. negative
B. positive

3. We've said that: A. Nature's fundamental building blocks are called__________. B. the smallest possible particle of such a material is called an__________________. C. the parts of the atom are __________, ______________, and__________________.	A. elements B. atom C. electrons, protons, neutrons (IN ANY ORDER)
4. Most materials--elements--hold together quite well. Therefore, we can state that the atoms of most elements are (stable/unstable--which?)____________________.	stable
5. Without going into further detail about elements and atoms, let's summarize by saying: A. elements are called Nature's fundamental______________. B. the smallest possible particle of an element is an__________. C. Most atoms are____________.	A. building blocks B. atom C. stable
RADIOACTIVITY AND NUCLEAR RADIATION 6. Most atoms are stable. But some natural atoms, and several we've been able to create, simply don't hold together well. These atoms are (stable/unstable--which?) ____________________.	unstable
7. Unstable atoms tend to break down. Parts of them can fly off into surrounding space in the form of energy. That's what radioactivity is...the spontaneous, uncontrollable breakdown of______________atoms.	unstable
8. The spontaneous, uncontrollable breakdown of unstable atoms, with a resultant energy release, is called ____________________.	radioactivity

8. The particles of energy that go flying off unstable atoms have a name of their own. <u>Since</u> the energy <u>is</u> released from the nucleus, or center, of the atom, the energy particles are called_____________ radiation.	nuclear
9. Once nuclear radiation starts, there's no way to stop it. It lives up to the definition of being (CHECK THE CORRECT ANSWER): ___A. controlled, gradual energy release. ___B. spontaneous, uncontrollable release of energy from an atom.	B is correct
10. We've said that: A. radioactivity is the spontaneous, uncontrollable breakdown of______ ____________________ B. the energy particles thus released are called__________________ ____________________________.	A. unstable atoms B. nuclear radiation
11. There are three types of nuclear radiation, and they're named after the first three letters of the Greek alphabet. The third one is gamma. Do you know the first two letters of the Greek alphabet?______________________	alpha, beta (If these were "Greek" to you, don't worry--we asked you to guess).
12. Alpha and beta radiation consist of actual particles that are electrically charged. But the third type is pure energy, similar to X-rays. So gamma radiation is often referred to as gamma____________________.	rays

RADIATION MEASUREMENT TERMS

18. Since radiation affects people, we must be able to measure its presence and relate the measurement to its physiological effect. The total amount of gamma radiation to which a person is exposed is called the dose, and the unit of dose measurement is the roentgen or milliroentgen (one thousandth of a roentgen). If a man is exposed to 5 roentgens of gamma on one occasion, and 6 more on another: A. the total of the two figures is his cumulative gamma radiation exposure_______________. B. his total dose is____________.	A. dose B. 11 roentgens
19. In gamma radiation exposure dose measurement: A. the unit of measurement is the ________________________. B. measurements can be made in thousandths of a unit, or ___________________________.	A. roentgen B. milli-roentgens
20. In writing exposure doses, roentgen is usually abbreviated with a capital "R", and it follows immediately after the number. A dose of 50 roentgens would be written___________________.	50 R
21. If John White has received a 15 R exposure to gamma radiation, his total exposure_______________ is 15 _________________________.	dose, roentgens
22. If the indicated dose is 15 mR, White has received a dose of 15 ___________ _______________________.	milliroent-gens

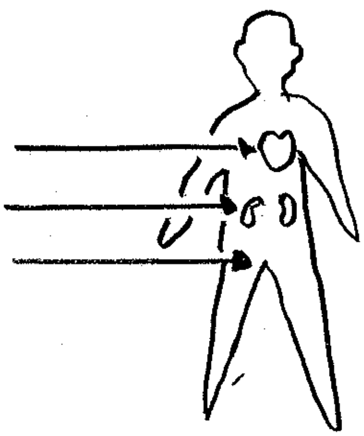
23. Another very important measurement of radiation is the rate at which an individual is exposed to gamma radiation. This is measured on a per-hour basis, and it's called the exposure dose__________.	rate
24.  The roentgen or milliroentgen is used for expressing the dose rate, too, except that the time involved must be included in the measurement. As the clock shows, the time unit is always an hour, and dose rates are expressed in terms of roentgens or milliroentgens per __________.	hour
25. In writing dose rates, "R" or "mR" stands for roentgen or milliroentgen: a "/" (slash) is used in place of "per"; and "hr" is used for the word "hour". A dose rate of sixty roentgens per hour would be written.________	60 R/hr
26. Write these doses and dose rates: A. dose of 12 milliroentgens, _______. B. dose rate of 100 roentgens per hour, __________. C. dose rate of 250 milliroentgens per hour, _________. D. dose of 100 roentgens, ______.	12 mR 100 R/hr 250 mR/hr 100 R
27. When exposure to radiation is being measured: A. the unit used to measure gamma radiation exposure dose is the ________ or the __________. B. the unit used to measure gamma radiation exposure dose rate is the ____________________ ____________________.	roentgen, milli-roentgen roentgen, per hour or milli-roentgen per hour

IMMEDIATE HAZARDS

1. The three types of nuclear radiation are represented by the drawings below. Label each type.

A.________________radiation must be ingested.

B.__________________ radiation can cause skin burns.



C.__________radiation can seriously damage vital internal organs due to its ability to penetrate so deeply.

A. alpha
B. beta
C. gamma

EXPOSURE OVER SHORT AND LONG PERIODS

3. To better understand radiation effects on the body, you should know the difference between short-term exposure and exposure over extended periods of time. For our purposes, we'll define a short-term dose as the dose received during a 4-day period. A dose of course, is (CHECK THE CORRECT ANSWER):

___A. the total exposure to radiation.
___B. the rate of exposure per hour.
___C. the amount of radiation the human body can withstand.

A is correct

4. Depending upon the size of the dose and the way an individual reacts to radiation exposure, a large short-term dose can mean serious illness or death. For example, a dose of 450 R can kill about 50% of a large group of people so exposed. This same dose, however, received over an extended period of time, would kill far fewer people. This tells us that (CHECK THE CORRECT ANSWER):

___A. a massive short-term dose is less dangerous than an equal dose received over an extended period.
___B. extended exposure can't be tolerated as well as short-term doses.
___C. small doses, received daily over an extended period of time, can be much better tolerated than the sum total of all such daily doses received in one short-term exposure.

C is correct

5. Assume both of these persons have been exposed to the same dose.

MAN A: feels slightly ill the day of exposure, then begins recovering.

MAN B: is quite ill for several days after exposure.

As these situations indicate, all people (do/do not--which?)________react the same to identical radiation exposures.

do not

6. As long as the subsequent short-term dose isn't too high (lethal) the body (can/cannot--which?)______________ repair some of the damage caused by radiation.

can

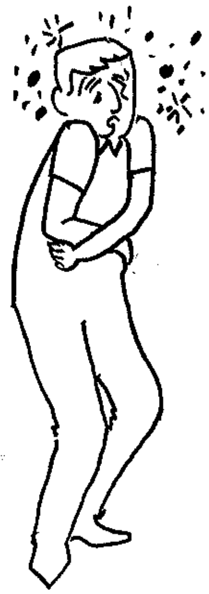
RADIATION SICKNESS SYMPTOMS

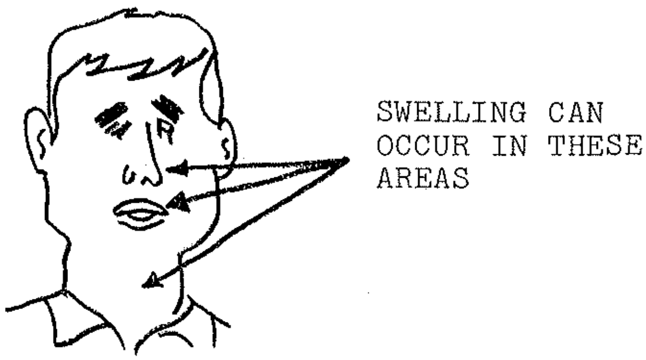
7. The symptoms to be discussed are those caused by short-term doses of gamma radiation from fallout. We'll relate some general symptoms to specified doses. These classifications must be general because people don't all react the same to an identical____________of radiation

dose

8. The symptoms we'll discuss are those that can be seen or readily measured--the (visible/invisible--which?) ______________signs of radiation sickness.

visible

9.  Two visible signs of radiation sickness are nausea and vomiting. But shock, or just pain, can cause a similar reaction. So, are nausea and vomiting necessarily an indication of radiation sickness? ______	no
10. You'll have to weigh the symptoms against the exposure received to determine whether they indicate radiation sickness. The symptoms we've discussed are ______ and ______.	nausea, vomiting (IN EITHER ORDER)
11.  This drawing illustrates the best way to detect a third radiation sickness symptom--a high ______ ______.	Temperature (OR) Fever
12. We've discussed three radiation sickness symptoms. List them. A. ______ B. ______ C. ______	nausea, vomiting, fever (IN ANY ORDER)

13. These symptoms resemble those of many common illnesses, including the "flu" and the common cold. You must judge them in terms of the amount of radiation exposure the person has had--his radiation exposure__________.	dose
14. Radiation sickness symptoms may appear shortly after exposure, then disappear for a few days--only to reappear in a week or so in much more serious form.  When they recur, the symptoms are sometimes accompanied by swelling in the passages of the______,______, and__________.	nose, mouth throat (IN ANY ORDER)
15. Once radiation sickness symptoms appear (CHECK THE CORRECT ANSWER): ___A. they may disappear, then reappear in a week or so, sometimes accompanied by nose, mouth, and throat passage swelling. ___B. they usually persist until death occurs. ___C. there is little or no hope for the individual, since the body cannot repair radiation-caused injuries.	A is correct

<u>DOSE-VISIBLE EFFECT RELATIONSHIPS</u> 16. Now, let's relate these visible effects to radiation exposure doses. These points are discussed as general rules only, since different people react (the same/differently--which?) ________ to an identical dose.	differently
17. On the next page, you'll find a chart depicting dose--visible effect relationships. Look the chart over at this time, reading it carefully; then return to the next frame on this page. NO WRITTEN RESPONSE REQUIRED.	NO WRITTEN RESPONSE REQUIRED
18. As the chart indicates, we're discussing the visible effects of (CHECK THE CORRECT ANSWER): ___A. short-term doses. ___B. doses received over extended periods.	A is correct
19. Look closely at the chart. See the Note on the term "group." A. There are usually no visible effects with doses up to about ________. B. Brief periods of illness may begin on the day of exposure in about 10% of a group, exposed to around ________. C. When doses exceed 450 R, ranging upward toward 600 R, you can expect (FINISH THIS SENTENCE). ________ ________ ________.	A. 50 R B. 75-100 R C. all to be ill, and most to die, in 1-3 weeks. (OR EQUIVALENT ANSWER)

DOSE -- VISIBLE EFFECT RELATIONSHIPS

Short-term dose	Visible effect
50 R	No visible effects
75-100 R	Brief periods of nausea on day of exposure in about 10% of the group.
200 R	As many as 50% of this group may experience some of the symptoms of radiation sickness. Although only 5% to 10% may require medical attention, no deaths are expected.
450 R	Serious radiation sickness in most members of the group followed by death to about 50% within two to four weeks.
600 R	Serious radiation sickness in all members of the group followed by death to almost all members within one to three weeks.

NOTE: As we have learned, all people do not react the same to identical radiation exposures. That is, some are more sensitive to radiation damage, while some may be less sensitive to such damage.

The term "group" as used in this chart refers to a number of people large enough that it would include individuals from the most sensitive to the least sensitive of all, to any dose or dose range.

20. So at least some brief illnesses in the group may be expected when the short-term dose is between ________ and ________.	75 R, 100R
21. If doses exceed 200 R--moving up toward 450 - 600 R --real problems develop. Death can occur, and serious illness is quite likely. So, while these guidelines are very general, you should try to avoid exposures that cause illness--those that exceed ________.	100 R
22. Keep this chart, if you wish. It provides you with (general/specific -- which?) ________ indications of dose-visible effect relationships.	general

PLEASE COMPLETE TEST ON THE NEXT PAGE

INTRODUCTION TO PEACETIME RADIOLOGICAL ACCIDENT AND INCIDENT MONITORING

HOME STUDY COURSE

NOTE: DO NOT LOOK AT THE TEST BELOW UNTIL YOU HAVE COMPLETED UNIT 1.

TEST

(Check the best answers)

1. The total amount of exposure to radiation is known as the:

   ___ a. dose rate.

   ___ b. dose.

   ___ c. biological effect.

2. The amount of radiation per hour is the:

   ___ a. dose.

   ___ b. exposure.

   ___ c. dose rate.

3. Radiation is measured in:

   ___ a. roentgens only.

   ___ b. BTUs.

   ___ c. roentgens or milliroentgens.

4. Some visible or measurable signs of radiation sickness are:

   ___ a. nausea, vomiting, fever.

   ___ b. diarrhea, jaundice, nervousness.

   ___ c. nausea, backache, headache.

5. If the radiation exposure dose greatly exceeds 450 R:

___a. most people will be able to continue with normal activities.

___b. everyone will probably be ill, most will probably die.

___c. everyone is certain to die immediately.

6. Most atoms are:

___a. stable.

___b. unstable.

7. Radiation that is similar to X-rays is called:

___a. alpha particles.

___b. beta particles.

___c. gamma radiation.

8. There are usually no visible effects from short term radiation if the dose is below:

___a. 200 roentgens.

___b. 50 roentgens.

___c. 400 roentgens.

9. The type of radiation that can cause serious damage to internal organs due to its ability to penetrate deeply is called:

___a. alpha particle.

___b. beta particle.

___c. gamma rays.

10. The type of radiation that must be ingested or inhaled to cause harm to the body is:

___a. alpha.

___b. beta.

___c. gamma.

WHEN YOU FINISH THIS TEST, CHECK YOUR ANSWERS USING THE ANSWER KEY ON PAGE 73 IN THE BACK OF THIS BOOK.

UNIT 2

C D RADIATION DETECTION EQUIPMENT

UNIT TWO

CIVIL DEFENSE RADIATION DETECTION EQUIPMENT

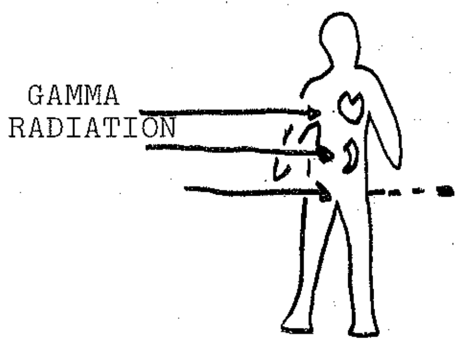
OVERVIEW

In this unit you will be introduced to radiation detection equipment available through your local Civil Defense agency. First, we will discuss radiation detection instruments in general. Then we will talk about such instruments as dosimeters, survey meters, etc., and how to use them.

You won't be able to practice with the instruments as part of the course because of the difficulty of shipping them to you. We'll go into enough detail, however, that you'll be able to recognize each instrument and the jobs they are designed to perform. Begin now with Frame 1.

TYPES OF RADEF INSTRUMENTS

1. The most dangerous type of nuclear radiation can penetrate (enter) the flesh and vital organs of an individual, doing great damage, and that person won't feel it.



That is, you wouldn't even feel ______________ radiation.

gamma

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2. Since gamma radiation can penetrate humans without being felt, we must have some means of determining how much radiation we're being exposed to. To detect and measure radiation we use radiological ______________.

instruments

---

3. We must have instruments to measure both factors of radiation exposure:

A. the total amount of exposure to radiation, or the exposure ________.
B. the amount of exposure received per hour, or the ______________.

A. dose
B. dose rate

---

4. The instrument for measuring dose is the dosimeter (dos - im -eter), and the dose rate is measured by the survey meter. Both measure in roentgens or ______________.

milliroentgens

5. To remember which instrument measures dose, just keep in mind that it begins with a part of the word itself. So the instrument that measures the total exposure dose to radiation is the (CHECK THE CORRECT ANSWER): ___A. Survey meter ___B. Dosimeter	B is correct
6. A dosimeter reacts to an increase in dose. If you're close to the maximum acceptable dose, you need to know immediately what your total __________ is.	dose
7. Survey meters require a minute or two to "warm up" before accurate readings can be obtained. These instruments react reasonably, quickly once they're warmed up. They'll register a change in about 15 seconds from the moment they're turned on. Survey meters measure the rate at which you're being exposed to radiation, or the __________.	dose rate
8. Once a survey meter is warmed up, it will react fairly quickly. If you move from one area to another, the change in dose rate can be read (CHECK THE CORRECT ANSWER): ___A. After about a 14-second wait. ___B. instantaneously ___C. in about 15 minutes	A is correct
9. A survey meter is so named because it's used to scan, or __________ , an area or surface to determine the exposure dose rate.	survey
10. Label these instrument descriptions with their names. _______________A. measures dose rate in R/hr or mR/hr. _______________B. measures accumulated exposure dose in R or mR.	A. survey meter B. dosimeter

11. The dosimeter measures in roentgens or milliroentgens. The survey meter, since it measures dose rate, measures in these units per ____________.	hour
12. The unit of measurement, while basically the same, varies in this respect: A. Since the dosimeter measures dose, the unit is the ____________ or ____________. B. Since survey meters measure dose rates, they measure in ____________ ____________ ____________ ____________	A. roentgen, milliroentgen B. roentgens per hour or milli-roentgens per hour.
13. Write "s" for survey meter or "d" for dosimeter beside each statement below: ___A. measures in roentgens or milliroentgens. ___B. measures in roentgens or milliroentgens per hour.	d A. s B.
DOSIMETERS 14. First let's talk about the radiological instrument that measures the accumulated exposure dose to radiation-- the ____________.	dosimeter
15. Under emergency conditions, a dosimeter should be worn on the person. Since you must know the dose to which you're being exposed, when on an outside mission, you (should/should not--which?) ____________ wear a dosimeter.	should

16. Dosimeters are only a half-inch in diameter, and the CD V-742, most often used for operational purposes, is less than 4 1/2" long. These instruments have a clip on them, similar to the clip on a pen, so they can be clipped on clothing, to belts, or in pockets. When on a mission, you should (CHECK THE CORRECT ANSWER):

___A. leave the dosimeter behind to avoid contaminating it.
___B. wear the dosimeter clipped to your clothing.

B is correct

17. Since dosimeters are used to measure dose, their scales read in (CHECK ANY CORRECT ANSWERS):

___A. roentgens per hour.
___B. milliroentgens.
___C. roentgens.
___D. milliroentgens per hour.

B & C are correct

18. Readings on a dosimeter represent the radiation exposure dose of the instrument. If an individual wears a dosimeter, we assume that his and the dosimeter's doses are (the same/different -- which?)______________.

the same

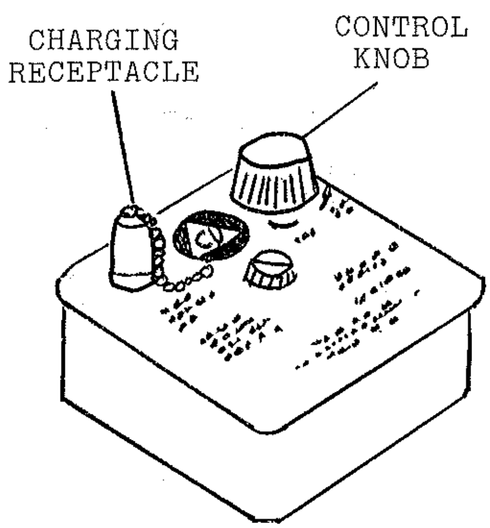
19. Dosimeter readings reflect the amount of radiation to which the instrument has been exposed. If such readings are to be considered accurate representations of the individual's dose, he must (CHECK THE CORRECT ANSWER):

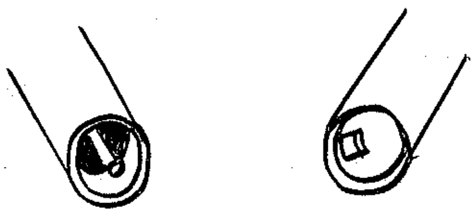
___A. leave the instrument alone so the reading on the scale won't be affected.
___B. wear the dosimeter at all times when in radiation areas.

B is correct

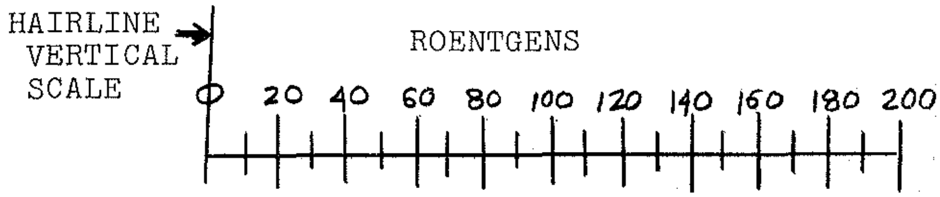
20. Dosimeters measure only the highly-penetrating type of nuclear radiation-- ______________ radiation.	gamma
21. Do dosimeters measure beta radiation? ______________.	No

CHARGING A DOSIMETER AND OBTAINING READINGS

22. A dosimeter doesn't have its own battery. Before it can be used, you must charge it. A special instrument has been developed for this purpose, and it's called--logically enough--a dosimeter______________.	charger
23. The dosimeter charger has been assigned the number CD V-750. It operates on power supplied by a single flashlight battery. On top of the charger are a charging pedestal (with cap on, here), a control knob, and one large screw, which holds the entire instrument  together. To charge a dosimeter, unscrew the cap and press the dosimeter down firmly on the charging______________.	pedestal

24.	The charging pedestal is capped to protect the contact from damage. To use a CD V-750 for charging a dosimeter: A. unscrew the protective cap of the ________________, then-- B. press the contact end of the dosimeter into it (firmly/gently--which?)________________.	A. charging pedestal B. firmly
25.	One end of a dosimeter has a contact for charging, and the other is a magnifying glass. By looking into the dosimeter through this glass end,  holding the instrument up to a light source, you can see the scale, magnified many times for easy reading. Since you must have a light source to shine through the dosimeter in order to read it, and since you'll have to read it while it's on the charger to set it properly, it follows that there's a ____________ in the dosimeter charger.	light
26.	When you press down gently on the charging pedestal, with the dosimeter and look into the glass end of the instrument, the light in the charger turns on and enables you to read the ____________ of the dosimeter.	scale

27. Here's what the scale of the operational dosimeter CD V-742



looks like. The vertical hairline mark tells you the radiation exposure ____________, shown here at ________________________.

dose, 0

28. The objective in charging a dosimeter is to make the scale read zero. Therefore, charging a dosimeter is often referred to as ____________ it.

zeroing

29. You'll see how easy charging a dosimeter is when you work with the instruments. For now, remember:

A. Charging a dosimeter is also called ______________ it.
B. Dosimeters are charged on a CD V-750 _________________.
C. To charge the instrument, you press its contact end onto the charging pedestal (gently/firmly--which?) __________________.

A. zeroing
B. charger
C. firmly

30. To read a dosimeter, aim it at a light source and look through it. If no other light source is available, the light in the charger used primarily for adjusting the hairline scale to zero may be used to read the dosimeter, (as will be more fully explained later.) Zeroing is accomplished by turning the control knob to the left or to the right, which moves the hairline along the horizontal _________________.

scale

31. At the beginning of its use, the dosimeter should read zero. To accomplish this (CHECK THE CORRECT ANSWER): ___A. hold the dosimeter in the charger until it reads zero. ___B. while holding the dosimeter firmly in the charger, adjust the hairline to zero by turning the control knob.	B is correct
32. Check your dosimeter after you take it off the charger. If the hairline has slipped a bit, you may have to put the instrument back on the charger and readjust the hairline. At the beginning of the period during which a reading is to be taken, the dosimeter should read ___________, if possible.	zero
33. When you press the dosimeter firmly onto the charging pedestal, a __________ comes on to enable you to read the scale.	light
34. You must have light coming through the instrument to read it. If no light source is available, you can use the charger for a source by pressing the dosimeter <u>gently</u> onto the charging pedestal. When charging the instrument, you must make sure contact is made by pressing ____________________.	firmly

35. When using the CD V-750 for a light source, the dosimeter's charging contact point shouldn't touch the contact on the charging pedestal. This is because the electrical charge from the charger will affect the position of the hairline, and you (CHECK THE CORRECT ANSWER): ___A. might change or lose the reading you're trying to obtain. ___B. could ruin the dosimeter.	A is correct
36. The CD V-750 has two important uses. A. It's used to zero, or_________, dosimeters, in which case the dosimeter should be pressed_____________onto the charging pedestal. B. Under poor light conditions, the charger can be used as a____________ source, in which case the dosimeter should be pressed onto the charging pedestal very_________.	A. charge, firmly B. light, gently
37. When reading a dosimeter, hold the instrument about half an inch from your eye and look into it. At the beginning of a specific mission or period for which you want to know the dose, the dosimeter should read _______________.	zero
38. If you've been wearing your dosimeter--and you should at all times in radiation areas--it probably won't read zero when you begin a mission or recording period. If you have time, zero it. But if you don't, you can determine the dose in a given period by (CHECK THE CORRECT ANSWER): ___A. wearing a dosimeter that reads zero, leaving your old one behind. ___B. reading the instrument at the beginning of the period, then subtracting that figure from the reading at the end of the period. ___C. adding the initial reading to the final reading for the period.	B is correct

39. When a dosimeter is charged, the hairline is held in place at zero by electrical charges on filaments in the instrument. Under certain conditions, the charge can leak from the dosimeter, resulting in a reading higher than zero. This loss of electrical charge is called ____________ leakage.	electrical
40. When the electrical charge on the filament in a dosimeter leaks off, the hairline will move up-scale. This reading is the result of electrical ____________.	leakage
41. You probably won't have any trouble with the phenomenon we're discussing. We're mentioning it mainly so that you'll know that stored dosimeters can show a reading, even if they were properly zeroed before storing, due to ____________.	electrical leakage
DOSIMETER CARE AND STORAGE 42. Like other radiological instruments, dosimeters are rugged enough to perform under almost any climatic conditions. They can take quite a bit of punishment. Still, to insure accurate, long-lasting life, you should handle dosimeters reasonably (roughly/carefully--which?) ____________.	carefully
43. Dosimeters and other radiological instruments are (CHECK THE CORRECT ANSWER): ___A. so rugged that you can't hurt them. ___B. rugged but can be damaged if misused.	B is correct

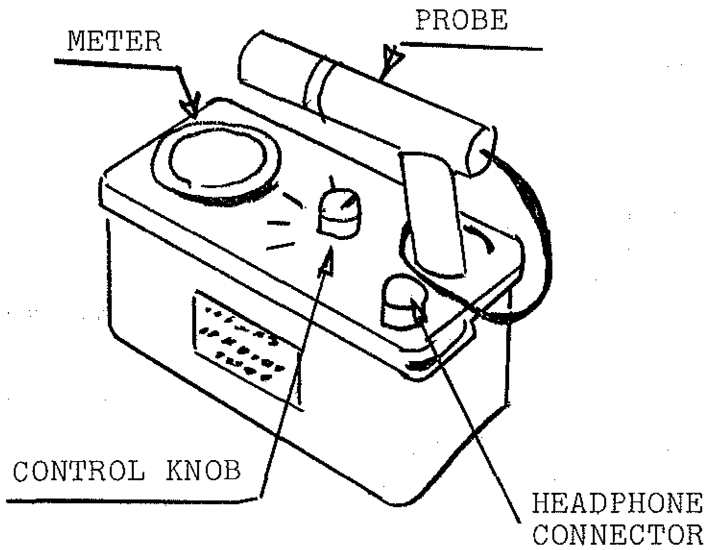
44. Exercise care in regard to contamination of dosimeters and other instruments. For your own protection, you (should/needn't bother--which?) ________ avoid instrument contamination.	should
45. Radioactive fallout particles are dangerous, no matter where they are located, so the monitor should avoid ________ of his instruments by fallout.	contamination
46. Contamination can occur, however. A dosimeter could be dropped in the dust, or handled with contaminated gloves. If an instrument becomes contaminated (CHECK THE CORRECT ANSWER): ___A. it should be decontaminated. ___B. it must be thrown away. ___C. you must leave it alone until radioactive decay occurs.	A is correct
47. You can decontaminate an instrument by brushing fallout particles off it. This is possible because fallout particles are (visible/invisible--which?) ________	visible
48. Remember in storing dosimeters that they operate on an electrical principle, so dampness can affect them. They should be stored in a location that is as ________ as possible.	dry

49. Dosimeters should be kept (charged/uncharged--which?) ______________ while in storage.	charged
50. An adequate storage location has probably been provided for your radiological instruments. The location should be (damp/dry--which?) ______________ and the dosimeters should be stored in a ______________ condition.	dry, charged
51. Stored dosimeters should be checked periodically---the frequency is established by your State Radiological Instrument Inspection, Maintenance and Calibration Program. When checking dosimeters, read them to see that they are still charged. They're charged when the scale reads ______________.	zero
52. A 200 R dosimeter should be recharged if you find the reading is 50 R or more when checked. In other words, stored dosimeters should be zeroed when the reading reaches (CHECK THE CORRECT ANSWER): ___A. one-third of full scale ___B. one-fourth of full scale ___C. one-half of full scale	B is correct

1. Civil Defense survey meters operate by means of a chamber of enclosed gas. When radiation passes through this gas, small electrical charges are released, causing a needle to move on a scale. The gas is enclosed in a ______________.	chamber
2. Survey meters have the same power source as the dosimeter charger CD V-750. That is, survey meters are powered by (CHECK THE CORRECT ANSWER): A. plugging them into a 110V outlet. B. 220V current only. C. ordinary flashlight batteries. (D-cell)	C is correct
3. Survey meters are used to measure the dose rate, so their scales read in roentgens or milliroentgens per__________.	hour
4. All CD survey meters can measure gamma radiation, and some of them can even detect beta radiation. Notice we said they can (under certain conditions) even detect the presence of____________radiation.	beta
5. Let's summarize what we've said about survey meters: A. They measure radiation by means of a small electrical current caused when radiation passes through gas in an enclosed____________________. B. They're powered by________________. C. They measure in________________or ______________________per hour. D. All measure____________________ radiation.	A. chamber B. batteries C. roentgens, milli-roentgens D. gamma

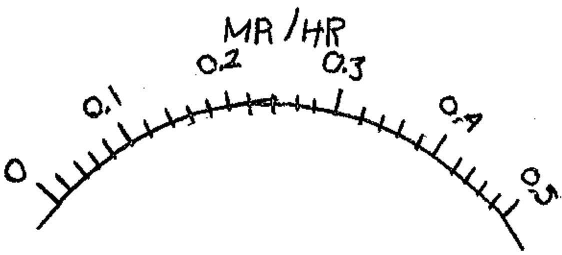
SURVEY METER CD V-700

6. This first survey meter is the CD V-700. As the illustration shows, there's just one control knob on the instrument. It also has a probe for monitoring close to objects; the meter; and a connector for a set of headphones. The CD V-700



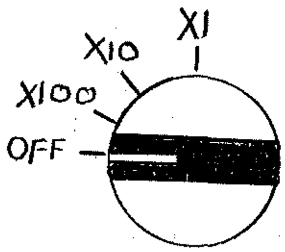
measures radiation in milliroentgens per hour, and its range is from 0 to 50 milliroentgens. This tells us that (relative to an instrument that measures in roentgens) the CD V-700 is a (high/low--which?) ______________ range instrument. | low

7. As this drawing of the CD V-700 scale shows, it reads in milliroentgens per hour, and it only goes up to 0.5 mR/hr.



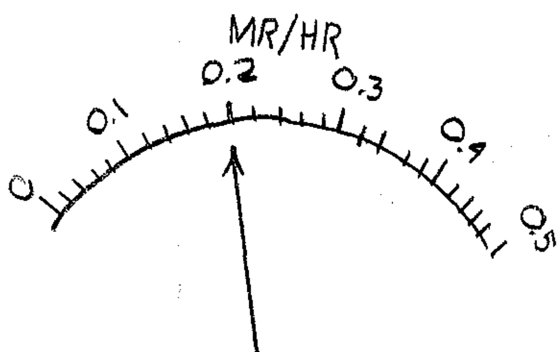
But earlier, we said its range is from 0 to 50 mR/hr, which would make the maximum (how mary)__________times that shown on this scale. | 100 times

8. This top view of the control knob shows how the CD V-700 can be used for readings up to 100 times (100X) the maximum scale reading of 0.5 mR/hr. The control knob can be turned to X1 (times one): X10 (times ten), or X100 (times one hundred), giving the CD V-700 a range of from 0 mR/hr to <u>100 times</u> the maximum scale reading, for a maximum reading of ______________.



50 mR/hr

9. When the control knob is set on X1, you read the dose rate directly from the meter. If the control is set on either of the other positions, you multiply the scale readings by the appropriate number.



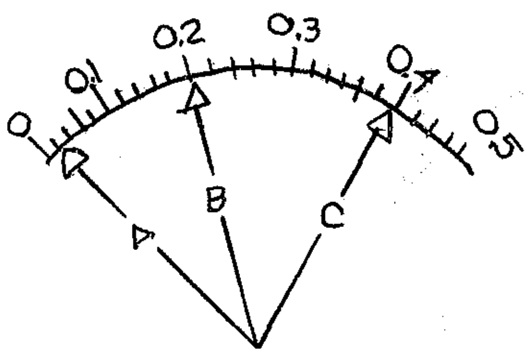
Look at this drawing and record the dose rates when:

A. the control knob is set at X1, ______________ mR/hr.

B. the control knob is at X10, ______________.

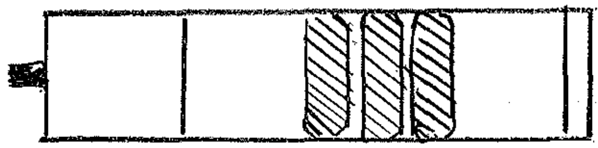
C. the control is set at X100. ______________.

A. 0.2
B. 2.0 mR/hr
C. 20 mR/hr

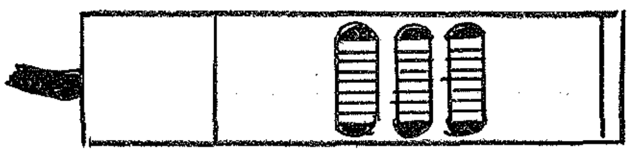
10. So far, we've said this about the CD V-700: A. It reads in ____________. B. The scale only goes up to ________ . C. Readings can be obtained directly from the scale on the ________ setting; should be multiplied by 10 on the ________ setting; and by 100 on the ________ setting.	A. milli-roentgens B. 0.5 mR/hr C. X1; X10; X100
11. The different settings of the control knob are called "ranges". The CD V-700 has a total of three ranges: X1, ________, and ________.	X10, X100 (IN EITHER ORDER)
12. On the scale below, there are three different dial indications, labeled A, B, and C. Determine the dose rate turned to the range indicated.  A. Range is X10, dose rate is ____________. B. Range, X100; dose rate, ____________. C. Range, X1; dose rate, ____________.	A. 0.2 mR/hr B. 20 mR/hr C. 0.4 mR/hr

13. When measuring a dose rate that is too high for the X1 range, you can turn the control to the X10 range, then multiply the indicated reading by ________.	10
14. If the dose rate is still too high to be read on the X10 range, you can turn the control knob to the ________ range, then multiply the indicated reading by ________. This range makes it possible to read up to ________ mR/hr, the maximum dose-rate-indicating capability of the CD V-700.	X100, 100 50, in that order
15. The range of an instrument is from zero to its maximum dose or dose rate indicating capability. The range of the CD V-700 ________.	0 to 50 mR/hr

16. The probe of the CD V-700 contains a Geiger tube encased in double metal cylinders. The tube, and the inside cylinder are rigidly attached to the base. This cylinder has an opening on one side at the sensitive area of the Geiger tube. The outside cylinder can be turned freely about the inside one. On one side of it, in a position to line up with the opening of the other cylinder, are large slotted openings.



A. Shield closed.



B. Shield open.

By turning the outside cylinder (or shield) one half turn, its slots can be lined up with the inside opening to the Geiger tube, making it possible to detect both beta and gamma radiation. Another half turn in either direction then, causes the closed side of the outside shield to cover the inside cylinder opening. With the shield in this position, the instrument measures only ________________ radiation.

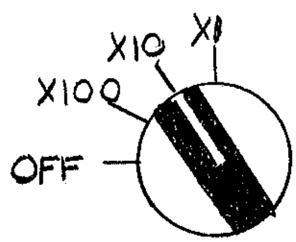
gamma

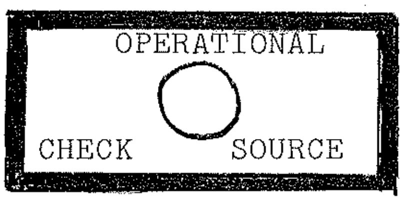
17. Even with the shield closed, some gamma radiation passes completely through the probe and is not detected; while some other gamma rays are absorbed in the probe, and therefore are detected. Most fallout beta rays cannot enter the probe when the shield is closed. Therefore, some gamma radiation is measured whether the shield is __________, or ___________. Beta and gamma normally can both be detected at once only when the shield is ________________.

open, closed, open

18. The shield on the probe makes little or no difference in gamma measurement. With the shield open, the reading may be a little higher than a reading in the same location with the shield closed. If this is true, the difference probably (is/is not--which?) ___________ due to the presence of beta radiation.	is
19. To detect the presence of beta radiation, you must have the CD V-700 shield (open/closed--which?)_________.	open
20. Although the CD V-700 is basically a training instrument, there will be a few operational applications for it. One of these is (CHECK THE CORRECT ANSWER): ___A. for long-range decontamination actions, when radiation levels have dropped quite low. ___B. during periods of peak radiation levels.	A is correct

CD V-700 OPERATIONAL CHECK

21. The first thing you must do before using a CD V-700 is to perform an operational check. First, turn the control knob to the range shown below.. the __________range.  	X10
22. Allow about 30 seconds for the instrument to warm up, leaving the control knob on the ________________range.	X10.
23. The first two steps in the CD V-700 operational check are: A. Turn the selector switch (or control knob) to the ______________range. B. Allow about ________________for warm-up	A. X10 B. 30 seconds

24.	Next, set the probe shield so the CD V-700 will detect both beta and gamma radiation. That is, turn the probe shield to the ____________ position.	open
25.	Order is important in this operational check. The points we've covered are: A. Turn the selector switch to the ____________ range. B. Allow ____________ for warm-up. C. Turn the probe shield to the ____________ position.	A. X10 B. 30 seconds C. open
26.	The next step involves the operational check source shown here.  This source is located on the opposite side of the instrument from the side containing the Civil Defense insignia, and it's used to make sure the instrument is working properly. This is a small source of ____________ material.	radioactive
27.	The operational check source is a bit of radioactive material on the side of the instrument case with which you can test the CD V-700. Once the instrument has warmed up, hold the open area of the probe as close as possible to the ____________.	operational check source
28.	With the open probe as close as possible to the operational check source, the meter on the CD V-700 should read somewhere between 1.5 and 2.5 mR/hr, averaging around the middle of this range--_____ mR/hr.	2

29. To see if the CD V-700 is working properly:

A. Hold the (closed/open--which?) ____________ area of the probe as close as possible to the ____________ ____________.

B. The meter reading may vary from ________ to ________ mR/hr, but should average around ____________ ____________.

A. open, operational check source
B. 1.5, 2.5, 2 mR/hr

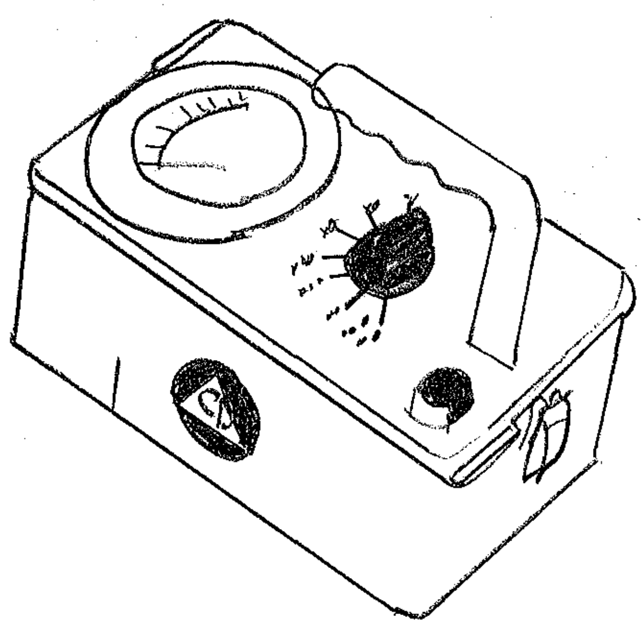
30. Complete these steps in the operational check for the CD V-700 survey meter.

A. Turn the selector switch to the ________________ range.
B. Allow ________________ for warm-up.
C. Rotate the probe shield to the ________________ position.
D. Place the open area of the probe as close as possible to the ________________ located on the (top/side--which?) ____________ of the instrument's case.
E. The meter should read between ____ and ________ mR/hr.

A. X10
B. 30 seconds
C. open
D. Operational check source, side
E. 1.5, 2.5

31. In an emergency, you'll perform operational checks as required by the circumstances. And in peacetime, your local CD system will have a regular timetable set up for checking instruments, such as bi-monthly or monthly. In any event, you can determine whether the CD V-700 is working properly by performing an ________________ check.

operational

32. The CD V-700 is built for rugged operation under almost any circumstances, but you should (CHECK <u>ONLY ONE ANSWER</u>): ___A. Handle the instrument as roughly as you wish--you can't hurt it. ___B. Keep it out of the sun, since it's easily affected by temperature. ___C. Both A and B are true. ___D. Exercise reasonable care in handling and storage.	D is correct
<u>SURVEY METER CD V-715</u> 33. Survey meter CD V-700 has a very low range--0 to 50 mR/hr. By comparison, the CD V-715 has a range of 0 to 500 R/hr, instead of mR/hr. In short, the CD V-715 is a ________range instrument.	high
34. Here's what the CD V-715 looks like.  A. An important difference between this instrument and the CD V-700 is the range of the CD V-715, which is 0 to __________R/hr.	A. 500

35. Write the number of each instrument beside its description.

_____________ A. Survey meter with a range of 0-50 mR/hr.
_____________ B. Operational dosimeter.
_____________ C. Survey meter with a range of 0-500 R/hr.

A. CD V-700
B. CD V-742 (OR 730 OR 740 OR EQUIVALENT)
C. CD V-715

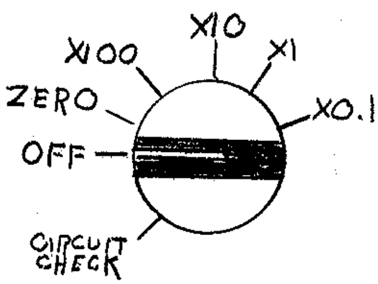
---

36. What is the range of the CD V-715 ____________________?

0-500 R/hr

---

37. Here's a top view of the selector switch for the CD V-715. It's more complicated than that of the CD V-700. In addition to "off," "zero," and "circuit check" (to be explained shortly) positions, there are four ranges...X100



________, ________, and ________.

X10, X1, X0.1 (IN ANY ORDER)

---

38. The ranges are used in the same manner as shown on the CD V-700. In other words:

A. on the X1 range, you multiply the reading by ________________.
B. on the X0.1, X10, and X100 ranges, you multiply the meter reading by _____, _____, and _____, respectively.

A. 1
B. .1, 10, 100

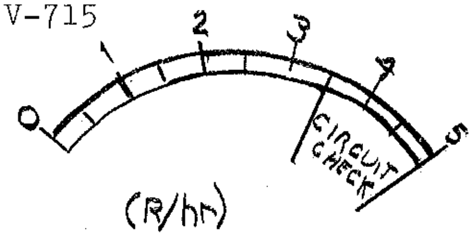
---

39. On the X1 range, you (CHECK THE CORRECT ANSWER):

___A. can just read directly from the meter.
___B. must always multiply by 1.
___C. should multiply by 0.1.

A is correct.

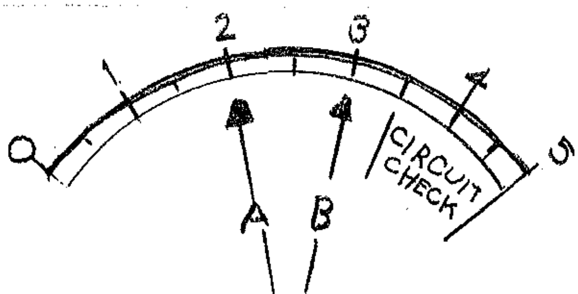
40. Here's a facsimile of the meter scale of the CD V-715



It runs from 0 to 5, and since there is a X100 range on the instrument, its range is ______ to _______ R/hr.

0, 500

41. On the CD V-715 meter shown below two arrows have been drawn--"A" and "B"--to represent two differenct readings.



Bearing in mind that the CD V-715 measures the dose rate in roentgens per hour, give the dose rates if:

A. for reading A, the meter is set on the X10 range---__________.
B. for reading B, the meter is set on the X100 range---__________.
C. for reading A, the meter is set on X0.1 range---__________.
D. for reading B, the meter is set on the X1 range---__________.

A. 20 R/hr
B. 300 R/hr
C. 0.2 R/hr
D. 3 R/hr

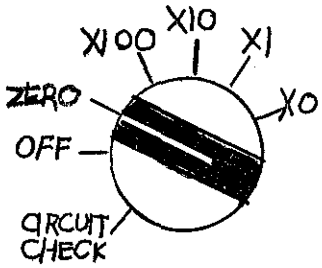
42. You'll have ample opportunity to practice readings in the in-class phase of this course. Remember, the survey meter CD V-715 measures the dose __________ in ________________.

rate, roentgens per hour (R/hr)

43. The instrument won't be affected by radiation when the switch is on "zero". So, even in heavily contaminated areas, you can check to see that your instrument's needle hasn't moved off the zero point by turning to the ________________ position.

zero

44. Even in areas of very high nuclear radiation, when the CD V-715 selector switch is turned to the position shown here, the instrument should read zero. This is because when the switch is set at the zero position, the instrument does not detect __________ __________.



nuclear radiation

---

45. If you test for zero and find that your instrument is reading above that mark, use the zero control knob, shown here, to adjust the needle back to __________.

ZERO CONTROL KNOB

zero

---

46. Note that the zero control knob is protected by raised shields on the case. This is to (CHECK THE CORRECT ANSWER):

___A. keep you from adjusting the needle too often.
___B. prevent accidental turning of the knob, which would result in inaccurate readings.

B is correct.

---

47. The final selector switch setting is the "circuit check." With the CD V-700, you were to check the instrument's operation by opening the probe shield and holding it as close as possible to the __________, at which time the meter should have read between _____ and _____ mR/hr.

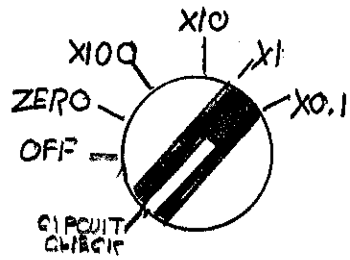
operational check source, 1.5, 2.5

---

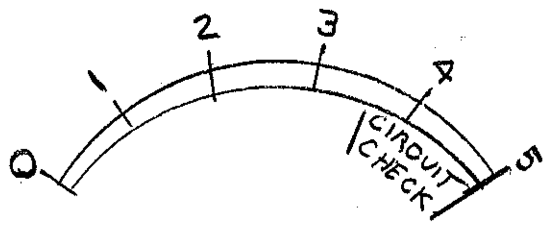
48. Checking out the CD V-715 is simplified, thanks to the circuit check feature. To make sure that the survey meter is functioning properly, just turn the selector switch to the circuit check position and look at the needle. It should point to the area of the scale that's marked "__________ check."

circuit

49. Assume that the selector switch is turned to the position shown here.



On the scale below, draw an arrow to indicate where the neddle should point.



Your arrow should point somewhere in the area marked "Circuit check".

CD V-715 OPERATIONAL CHECK

50. You must learn the steps of the CD V-715 operational check in order, so pay close attention. The first step is to turn the selector switch to the zero position. At this position, the instrument should always read ________________.

zero

---

51. Next, wait a minute or two for the instrument to warm up. Instruments vary as to warm-up time required, but a safe period is usually about two ________________________.

minutes

---

52. The first two steps in the CD V-715 operational check are:

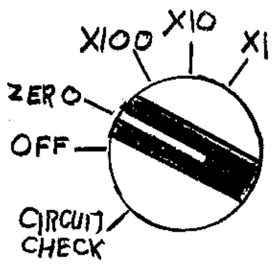
A. Turn the selector switch to the ______________ position.
B. Allow about __________ for warm-up.

A. zero
B. 2 minutes

53. Next, make any necessary correction in the meter reading. To do this (CHECK THE CORRECT ANSWER): ___A. turn the zero control knob as necessary to make the meter read zero. ___B. turn the selector switch as needed.	A is correct.
54. The first three steps in the operational check of the CD V-715 are: A. Turn the selector switch to the __________ position. B. Allow about ________ for warm-up. C. Adjust the ________ knob so the meter reads ________.	A. zero B. 2 minutes C. zero control, zero
55. The fourth step is to turn the selector switch to the circuit check position. When the switch is turned to this position, the needle should point to the area marked ________ on the meter.	circuit check
56. If the needle doesn't point to the circuit check portion of the meter, you know that something's wrong--quite probably the instrument needs new batteries. At any rate, you know that: A. when the ________ switch is turned to circuit check... B. the needle indicator should point to ________ on the indicator.	A. selector B. circuit check
57. Finally, turn the selector switch to each range--X100, X10, X1, and X0.1-check that the meter is registering zero on each range. Recheck for zero on the zero position after checking all ranges. In other words, you check for zero in the ________ position both before and after checking all other ranges for ________.	zero, zero

58. Complete these statements comprising the operational check for the CD V-715. A. Turn the selector switch to_________. B. Allow about ________________for warm-up. C. Adjust the zero control knob so the meter reads ____________. D. Turn the selector switch to the ___________________position-- the needle should point to the _______ portion of the meter. E. Finally, turn to each of the four _____________and recheck for ____________ on the ______________ after each range check	A. Zero B. 2 minutes C. zero D. circuit check, circuit check E. ranges, zero, zero

SURVEY METER CD V-720

59. Survey meter, CD V-720, is a high range meter much like the CD V-715. It has a range of 0 to 500 R/hr. The important difference between the CD V-715 and the CD V-720 is that the CD V-720 has the capability of detecting beta radiation. NO RESPONSE REQUIRED.	
60. Here is a top view of the selector switch for the CD V-720. You will note it has one less position than the CD V-715. In addition to "off", "zero", and "circuit check", there are three ranges X100, ________ and ________. These ranges are used in the same manner as the CD V-700 and the CD V-715. 	X1, X10 (IN EITHER ORDER)
61. The operational check of the CD V-720 is the same as the CD V-715. The first step is to turn the selector switch to________. Next wait______minutes. Then zero the meter. The last step is to turn the selector switch to circuit check. The needle should then point to the area marked________on the meter.	zero, two, circuit check
62. The window of the ion chamber is a very thin (0.006 in.) aluminum disc. This thin window will allow beta radiation to pass thru there by allowing the CD V-720 to detect__________ radiation.	beta

64. Because beta radiation will not penetrate the shield, the shield must be ________ to detect beta radiation. If the radiation reading is a little higher with the shield open than with the shield closed, this is probably due to the presence of ________ radiation.	open, beta

STORING INSTRUMENTS

65. You learned that dosimeters should be stored in a charged condition in a dry condition. There are additional precautions you must take, however, when storing survey meters. These precautions are necessary because of the instruments' power source, which is the ______________.	flashlight battery (OR) D-cell (EITHER ANSWER IS CORRECT)
66. Batteries have a tendency to leak or corrode if allowed to sit for long periods, so it's wise to (CHECK THE CORRECT ANSWER): ___A. remove batteries from instruments that are not in use. ___B. leave batteries in place at all times so the instruments will be ready for instant use.	A is correct
67. Batteries are easy to install in an instrument. When the instrument is not in use, batteries should be ______________.	removed
68. In the in-class portion of this course, you will learn how to install batteries in radiological instruments. You'll find that the most important thing is to match the plus and minus poles of the batteries with the same signs in the instruments. In other words, you must be careful to install batteries so that __________ (like/unlike--which?) pole signs on the batteries match these in the instrument.	like
69. Since battery installation is simple, and because batteries can damage your instruments when stored for long periods, you should (FINISH THIS SENTENCE) ______________	remove batteries before storing instruments (OR EQUIVALENT ANSWER)

70. Stored instruments should be inspected periodically. Dosimeters should be rezeroed, and battery connections in other instruments should be inspected and cleaned as necessary. Normally, your local CD organization will have a regular schedule for you to follow in instrument ______________.	inspection
71. In regard to inspection of stored RADEF instruments (CHECK THE CORRECT ANSWER): ___A. the monitor should inspect them when he thinks of it. ___B. you should follow your local organization's SOP (standing operating procedures) for inspection.	B is correct
72. You may sometimes carry instruments for periods of time without using them. When you do, you can avoid running the batteries down by turning the switch off all ranges. The instrument's selector switch should be turned to the ____________ position.	off
73. When an instrument is in storage (CHECK ANY CORRECT ANSWERS): ___A. batteries should be left in so the instrument will be ready for immediate use. ___B. battery contacts should be inspected and cleaned as necessary. ___C. it should be turned on to be ready for instant use. ___D. the batteries should be removed. ___E. battery contacts should be left strictly alone so good connection will be assured.	B and D are correct.
74. You will be given time to practice with radiological instruments in the in-class (practical exercise) portion of your radiological monitoring course. You should have no trouble answering the questions on the test for this unit. If any parts give you trouble, don't hesitate to return to the program for review. NO RESPONSE REQUIRED. PLEASE COMPLETE TEST ON PAGE 53.	NO RESPONSE REQUIRED.

1. The survey meter measures:

____a. dose rates.

____b. doses.

____c. alpha radiation.

2. Before use, a dosimeter should be charged or:

____a. plugged in for an hour.

____b. connected to a battery carried by the monitor.

____c. zeroed on a dosimeter charger CD V-750.

3. If an instrument becomes contaminated by radioactive material:

____a. throw it away.

____b. avoid using it until radioactive decay takes place.

____c. decontaminate it by wiping or brushing fallout particles off.

4. A charged or zeroed dosimeter can show a reading after a period of time, even without the presence of radiation due to:

____a. automatic discharge.

____b. electrical leakage.

____c. dry air in the storage location.

5. Radiation detection instruments are:

____a. very fragile, easily broken.

____b. sturdy, but should nevertheless be handled carefully.

____c. impossible to harm.

6. Once dosimeters are charged and stored:

____a. they should be checked and recharged, if necessary, periodically.

____b. they needn't be checked again.

____c. the monitor has no further responsibility toward them.

7. Dosimeters should be stored in a:

____a. damp location.

____b. dry location.

____c. location that's far away from any potential targets of nuclear attack.

8. All CD survey meters:

____a. detect alpha radiation, measure beta and gamma.

____b. measure gamma radiation.

____c. measure gamma, and detect alpha and beta.

9. When a survey meter is set on the X1 range:

____a. you must multiply the meter reading by 10.

____b. you can read directly from the meter scale.

____c. the instrument is inoperable.

10. When the shield on the CD V-700 is open, it detects:

____a. gamma only.

____b. no radiation.

____c. gamma and beta radiation.

11. Before using a survey meter, you should:

____a. recharge it.

____b. decontaminate it.

____c. run an operational check.

12. The range of the CD V-715 is:

____a. 0-50 mR/hr.

____b. 0-50 R/hr.

____c. 0-500 R/hr.

13. Whenever you turn to the zero range on a CD V-715:

____a. the instrument should read zero, regardless of radiation levels.

____b. background radiation will determine what the instrument will read.

____c. the instrument will read 100 R/hr.

14. When survey meters are stored for long periods:

____a. they needn't be checked out.

____b. batteries should be removed to protect contact points.

____c. batteries should be left in so the instruments are ready for immediate use.

15. Instruments should be inspected:

____a. only when you think it's necessary.

____b. when you're told to do so by the Office of Civil Defense.

____c. according to the schedule established by your community CD organization.

When you have completed this test, check your answers with the Answer Key on page 73 of this book.

UNIT 3

PROPERTIES OF RADIOACTIVE MATERIAL

UNIT THREE

PROPERTIES OF RADIOACTIVE MATERIAL

OVERVIEW

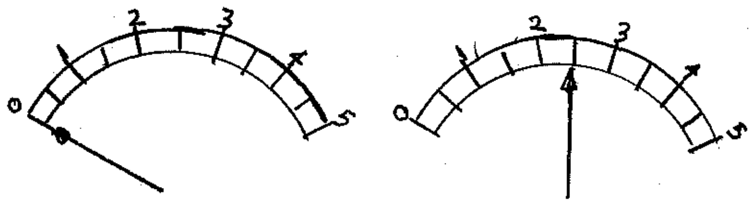
In this lesson we will discuss ionization and how ionization is used to measure radiation. We will also learn about alpha and beta particles and their effect on the body. Begin Frame 1.

1. Radioactive material on a surface does not contaminate that surface itself. If radioactive material lands on a window ledge, for example, the particles (CHECK THE CORRECT ANSWER): ___A. permanently contaminate the ledge. ___B. are radioactive, but the ledge is not. ___C. are no longer dangerous.	B is correct.
2. If radioactive material or nuclear radiation passes through the air, the air itself (does/does not--which?)_____________ become radioactive.	does not
IONIZATION 3. Shortly after the discovery of radioactivity, it was learned that exposure to radiation causes gases to ionize. Simply put, the atoms of gases change their radiation. As you might imagine, the greater the amount of radioactivity the gas is exposed to, the (greater/smaller--which?)___________________ the change in electrical charge.	greater

4. This ionization phenomenon was used quite early--by Madame Curie, in fact--for comparing the radioactivities of different materials. For example, if the electrical charge of a gas was changed X-amount by the radioactivity from Substance A, and was changed by 2X by the radioactivity from Substance B, it would indicated that (CHECK THE CORRECT ANSWER): ___A. Substance A was more radioactive than Substance B. ___B. Substance B was more radioactive than Substance A. ___C. There was little difference in the radioactivity of the two substances.	B is correct.
5. The change in electrical charge caused by exposure to radiation has been most useful in developing instruments that measure radioactivity. Remember, this change in the charge of an atom is called ________________, and it occurs in (solids/liquids/gases) ______________________________.	ionization, gases
6. To use this phenomenon in measuring the amount of radioactivity present in an area, an instrument must have some means of detecting and displaying the change in __________________ of a gas.	electrical charge
7. The survey meters we discussed earlier are ionization instruments. They are capable of detecting the charge in trapped gas and displaying this change by means of electrical meters--the dials you read when using the instruments. There's nothing special about the gas used in the instruments. Almost any gas would work, so we use the one that's most available--___________________.	air

8. Let's look at an operational survey meter, the CD V-715, to see how one type of ionization instrument works. This instrument has a metal cylindrical-shaped gas chamber. You learned earlier that: A. alpha and beta particles of radiation (will/won't--which?) ________________ penetrate metal, so... B. the CD V-715, with its metal__________ chamber, measures__________radiation.	A. won't B. gas, gamma
9. Within the gas chamber of the CD V-715 survey meter, there's a disc called a <u>collector</u>. There's a potential electrical charge difference of about 125 volts between the collector and the chamber itself. Now, when radioactivity passes through the gas in the chamber, the atoms of the gas become ionized--their______________changes.	electrical charge
10. The ions created when radioactivity passes through the gas in the metal gas chamber (or ionization chamber) are positively charged. They then go to the disc in the chamber--they're drawn to it by electromagnetic attraction. The disc, as mentioned, is called the ________________and since the positively-charged ions go to it, we know that the disc is (positively/negatively--which?) ___________________charged.	collector, negatively
11. So the ions, or electrically charged particles, are drawn to the collector, a disc of (the same/a different) ____________________electrical charge.	a different

12. The number of ions created is directly proportionate to the amount of radio-activity passing through the gas in the chamber. The electrons from these ions, once collected on the disc, createв an electrical charge.



NO CURRENT   CURRENT

This current then passes into the measuring circuit of the instrument, where it's amplified and operates an electric meter. In other words, the electrons from the collected ions result in a current which, when amplified, causes what's pictured above to happen--the instrument's______________ shows a reading.

meter

13. The radioactivity passing through the gas in the chamber, then causes ionization of the gas atoms. This results in an imbalance of electrons in these atoms, which gives them an electrical charge.

A. The charge of the ions is the opposite of the____________________, which is a disc in the chamber.
B. Therefore, the ions (avoid/are collected on/move around)__________________________ the disc.
C. The electrons from these ions create an ______________________charge which, when amplified, operates an electric ______________________--the part of the instrument you read.

A. collector
B. are collected on
C. electrical, meter

14. The current we're talking about in this type of instrument is quite low, of course. Therefore, before it can cause the needle on the meter to move, it must be (reduced/amplified)____________________.

amplified

15. In a few minutes, we'll discuss the properties of the three different types of radioactive particles--alpha, beta, and gamma. But you already know enough to answer this question:

Since we're talking in this instance about ionization of gas within a metal chamber, which type of radioactivity will such an instrument measure?__________ Why? ____________________________.

gamma--the other two won't penetrate the metal of the chamber

16. Remember the CD V-700? As you'll recall, this instrument measures very small amounts of radioactivity, so it's considered an (operational/training)_______________ instrument only, for all practical purposes.

training

17. This instrument operates on the ionization principle, like the CD V-715 and other operational instruments. But it measures beta radiation, as well as gamma, as you'll probably remember. How? Well, the shield on the probe of the CD V-700 can be turned, as we discussed.

SHIELD CLOSED

SHIELD OPEN

With the shield closed, the probe is a metal ionization chamber, so it'll only measure ________________ radiation.

gamma

18. Now, beta radiation will penetrate glass. When the shield on the probe of a CD V-700 is open, there's a glass chamber inside the metal one. So when this glass is exposed--the shield is open--the instrument (CHECK THE CORRECT ANSWER): A. measures only the gamma radiation anyway. B. measures beta only. C. measures both the gamma and beta radiation passing through the chamber. D. measures neither type of radiation, since the instrument won't work without its protective shield.	C is correct.
19. With the shield open, the CD V-700 measures both the gamma and beta radiation passing through the enclosed gas. To determine the amount of beta, of course, you'd have to take both readings--open and closed shield--and find the difference. The point is, due to the glass chamber that can be exposed, an instrument such as the CD V-700 can measure both ____________ and ________________ radiation.	beta, gamma
20. These instruments operate on the same principle as the others we've discussed--those with metal chambers only. That is, the radioactivity passes through the gas in the chamber (whether the shield is open or closed is not important to this point) and causes ______________ of the atoms of the ________________________________.	ionization, gas

21. This type of meter operates at a higher voltage than the others, and this means that there's a greater difference in charge between the collector and the ionized particles. It follows, then, that the ions move to the collector at a much (faster/slower) ________________ rate than in the other type of instrument.	faster
22. Due to this greater acceleration of ions, the instruments with a glass-and-metal ionization chamber will measure much smaller amounts of radioactivity...the instruments are more sensitive. That's why they're capable of detecting ________________ radiation, as well as gamma.	beta
23. The greatly accelerated ions in instruments like the CD V-700 (these are Geiger-Mueller counters, for your information) collide with other gas atoms on their way to the collector, ionizing them as well. And all of this activity creates an electrical current. The electrical current thus created is what causes the meter to show a reading. And since the built-in acceleration effect created in these ionization chambers causes so much electrical activity, the current thus created (must/should/need not) ________________ be amplified before it can cause a reading on the electrical ________________ of the instrument.	need not, meter

24. Both types of instruments we've discussed--those with all-metal gas chambers, and those with metal and glass chambers--operate on the same principle. Radioactivity passes through the gas in the chamber and ionizes the gas, thus creating electrical current that is capable of moving the needle of a meter. But with the all-metal chamber, the current created is not as great as that which results in the other instruments. Therefore:

A. In an instrument like the CD V-715, the current must be _______________ before it can move the needle of the meter.
B. In an instrument like the CD V-700, the current is greater so it (FINISH THIS SENTENCE)

_______________________________________.

A. amplified
B. need not be amplified
(OR SIMILAR ANSWER)

25. So the fact that radioactivity causes ionization of the atoms of gas in a chamber is especially important to us in detecting and measuring radiation levels. This phenomenon is the principle upon which some of our most useful instruments--especially _____________________ meters--are constructed.

survey

26. A whole program--and more--could be written on this subject of ionization, and how it applies to the instruments we use in measuring radioactivity. But we've gone far enough for our purposes here. Remember, the survey meters you'll work with are electrical instruments, and the electrical energy that causes a reading on the meter of such an instrument is created by (CHECK THE CORRECT ANSWER): ___A. 110V current from any wall outlet. ___B. batteries. ___C. ionization of the atoms of gas in a chamber.	C is correct.
PROPERTIES OF RADIOACTIVE PARTICLES 27. Directly related to the ionization of gases caused by radioactivity are the properties of the types of radioactive particles. There are three types of these particles, as we've discussed: __________, __________, and __________.	alpha, beta, gamma
28. Alpha particles are rapidly-moving particles of positive charge. They're actually nuclei of helium atoms--but we don't expect you to remember that. As we've already discussed, alpha particles (will/will not) __________ penetrate metal or glass, so it (can/cannot) __________ be measured with the survey meters we've been discussing.	will not, cannot
29. Alpha particles are fast moving, as mentioned ...they're shot out at speeds of about 10,000 miles per second. You'll learn soon that this is actually slow, compared to beta and gamma particles, even though it sounds incredibly fast at this time. But alpha particles lose speed quickly, because they run into atoms in their path. So, in spite of their initial speed, they travel only an inch or two! This is one of the reasons we said earlier that we (are/aren't __________ especially concerned about alpha radiation.	aren't

30. For injury to result from alpha radiation, you'd almost have to swallow (inhale, ingest) alpha particles. This is because they travel (CHECK THE CORRECT ANSWER): A. too fast to cause damage. B. only very short distances. C. quite far.	B is correct.
31. Alpha particles cannot penetrate the chamber wall of a survey meter--it can't reach the gas trapped in the chamber. Therefore, for all practical purposes, alpha radiation (can/cannot) _______________ be measured on our instruments.	cannot
32. Beta particles move much faster than alpha--at speeds of about 184,000 miles per second. But, as we discussed earlier (CHECK THE CORRECT ANSWER): A. beta penetrates neither metal nor glass, so it can't be measured. B. beta penetrates metal, but not glass. C. beta penetrates glass, but not metal, so it is detected only by our Geiger-Mueller counters.	C is correct.
33. Beta particles can penetrate thin sheets of metal, and pass through glass fairly easily. They may even penetrate as far as half a centimeter into lead. The important aspect here is that these radiations will pass through glass, so they can be detected using the CD V-700, as long as the shield on the instrument's probe is (open/closed) ______________________.	open

34. Finally, gamma radiation consists of rays similar to X-rays. It's a form of electromagnetic radiation of very high frequency. A. Gamma rays (will/will not)____________ penetrate metal, including centimeters of that very dense metal,_______________. B. For this reason, gamma rays can be detected and ultimately measured through the ________________ of the atoms of gas, even if it's in a metal chamber.	A. will, lead B. ionization
35. Gamma rays travel at the speed of light, so they're much faster than both alpha and beta radiation particles. They can cause chemical and biological alterations in living cells and tissues, so they're especially dangerous. Still, it's this ability to penetrate that also makes gamma rays (easier/more difficult) ________________ to detect and measure.	easier
36. Alpha and beta radiation are actually particles which shoot out at tremendous speeds. But gamma radiation is more like X-rays. In this regard, then, gamma radiation is (CHECK THE CORRECT ANSWER): ___A. also composed of visible particles. ___B. made up of rays of electromagnetic radiation of very high frequency. ___C. low-frequency rays of electromagnetic radiation.	B is correct
37. As we discussed in a previous section, beta radiation can penetrate only a slight distance into the skin. It can produce an effect similar to a burn on the skin's surface. But gamma rays are capable of penetrating (CHECK THE CORRECT ANSWER): ___A. a little bit farther into the body. ___B. no farther than beta radiation. ___C. completely through a person's body.	C is correct

38. But this same penetrating capability of gamma radiation is the same thing that makes it possible for us to detect and measure gamma radiation. If it couldn't penetrate the metal ionization chambers of instruments such as the CD V-715, we (could/could not) ________ use such instruments to detect and measure ________ radiation.	could not, gamma
39. Concerning the properties of the three types of radiation: A. Alpha particles travel (very short/long) ________ distance through the air. B. We do not use an instrument that measures or even detects the presence of ________ radiation. C. Beta particles travel (longer/shorter/about the same) ________ distances, compared to alpha radiation. D. Gamma radiation is ________ radiation similar to ________. E. Gamma rays (can/cannot) ________ penetrate seemingly solid materials.	A. very short B. alpha C. longer D. electromagnetic X-rays E. can
40. So the penetrating capabilities of gamma and beta radiation make it possible to detect and measure them (directly in the case of gamma; indirectly for beta) using the ionization of gases phenomenon we've discussed. As you can imagine, the properties of each of these types of radiation are the subjects of many complete books, so we could continue indefinitely with this subject. But you now know enough to understand how and why we can detect and measure beta and gamma radiation--and why we can't measure alpha radiation with most of our instruments. So let's end this unit at this point; when you're ready, take the quiz, which follows. NO RESPONSE REQUIRED.	NO RESPONSE REQUIRED

PLEASE COMPLETE THE TEST ON THE FOLLOWING PAGES.

INTRODUCTION TO PEACETIME RADIOLOGICAL ACCIDENT AND INCIDENT MONITORING

HOME STUDY COURSE

NOTE: DO NOT LOOK AT THE TEST BELOW UNTIL YOU HAVE COMPLETED UNIT 3.

TEST

(Check the best answers)

1. When radioactive particles land on a surface or pass through the air:

    ____a. the material they pass through or land on becomes permanently radioactive.

    ____b. the surface, or the air, is radioactive for only a short period of time.

    ____c. the air or the surface isn't radioactive, but the particles are.

2. Radioactivity which causes a change in the electrical charge of the atoms of gases is a phenomenon called:

    ____a. nuclear fission.

    ____b. ionization.

    ____c. radioactive decay.

3. In the OCD survey meter that has an all-metal ionization chamber, there's a disc called a collector on which:

    ____a. dust and other impurities are collected.

    ____b. positive electrical charges are repelled.

    ____c. positively-charged ions are collected.

4. In instruments that have all-metal chambers:

    ____a. the electrical current generated by the ions is small and must be amplified before it can operate the meter.

    ____b. no electrical current is allowed to reach the meter portion of the instrument.

    ____c. it's not necessary to amplify the current created by the electrons.

5. In a Geiger-Mueller counter, which has a tube inside the metal probe:

____a. only alpha radiation can be measured.

____b. only gamma radiation can be detected.

____c. beta radiation, as well as gamma can be detected.

6. A Geiger-Mueller type survey meter is:

____a. much less sensitive than the instruments with all-metal ionization chambers.

____b. more sensitive than the other type of meter.

____c. about the same, in terms of sensitivity, as the other type of survey meter.

7. The highly-penetrating nature of gamma rays:

____a. makes them relatively easy to detect with survey meters.

____b. makes them almost impossible to detect and measure.

____c. has no bearing on the ability to detect and measure with survey meters.

8. Civil Defense instruments will not detect or measure:

____a. alpha particles.

____b. beta particles.

____c. gamma rays.

9. The type of radiation that can cause skin burns if left on the skin's surface:

____a. alpha particles.

____b. beta particles.

____c. gamma rays.

10. With the shield open on the CD V-700, it will:

____a. measure beta radiation.

____b. detect alpha radiation.

____c. detect beta radiation.

WHEN YOU HAVE COMPLETED THIS TEST, CHECK YOUR ANSWERS WITH THE ANSWER KEY ON PAGE 73 OF THIS BOOK.

INTRODUCTION TO RADIOLOGICAL MONITORING FOR PEACETIME ACCIDENTS OR INCIDENTS

HOME STUDY COURSE

ANSWER KEYS
for
UNIT TESTS 1-3

UNIT 1	UNIT 2	UNIT 3
1. B	1. A	1. C
2. C	2. C	2. B
3. C	3. C	3. C
4. A	4. B	4. A
5. B	5. B	5. C
6. A	6. A	6. B
7. C	7. B	7. A
8. B	8. B	8. A
9. C	9. B	9. B
10. A	10. C	10. C
	11. C	
	12. C	
	13. A	
	14. B	
	15. C	

NOTICE TO THE STUDENT

CONGRATULATIONS!!!

AT THIS POINT YOU HAVE COMPLETED THE THREE REQUIRED UNITS OF THE INTRODUCTION TO RADIOLOGICAL MONITORING FOR PEACETIME ACCIDENTS OR INCIDENTS HOME STUDY COURSE.

YOU ARE NOW ELIGIBLE TO TAKE THE FINAL EXAMINATION. TO DO SO YOU MUST COMPLETE ALL OF THE CARD ON THE LAST PAGE OF THIS TEXT. UPON RECEIPT OF THE CARD THE EXAMINATION WILL BE SENT TO YOU. YOU WILL BE AWARDED A CERTIFICATE UPON SUCCESSFUL COMPLETION OF THE EXAMINATION.