ON-LINE DOE RCT CORE TESTING

To get started you must go to web address shawneerct.com. First you must register (It does not cost anything to register). Once you have registered and have you login ID and password please put away your ID and password for future reference. Next you must decide if you want to take the RCT course or challenge the DOE Overall Exam. The cost for each of the 13 module courses are $20 each (3 attempts to pass test per module). If a student fails the DOE Overall Core Exam and fails any one particular module, then the student should take that module for remediation prior to taking next attempt at Overall Core Exam. (see attached Short Core Study Guide)

If an individual fails any one test three times, that person is banned for six months from DOE Core qualification thru Shawnee Environmental Services, Inc. (SES, Inc.).

If an individual decides to challenge the DOE Overall Core Exam (the cost is $150 for three chances to pass a proctored exam) then that individual must contact SES, Inc. (937-572-9704/9706 or email admin@shawneerct.com) to arrange for a proctor for their exam.

To take any exam the individual must log in on the Home page for shawneerct.com. Once the individual is logged in, then choose from the menu for Core Courses, Site Courses, or the DOE Overall Core Exam. To take the Overall Core Exam: the proctor must be approved by admin@shawneerct.com prior to exam start to give individual's user ID access to testing database. When student takes exam, the results will be reviewed by student where any challenges may be emailed to admin@shawneerct.com.

Exam results are not final until student test challenges and the proctor's email have been received and reviewed by admin@shawneerct.com. When student passes exam, the proctor will be emailed the student's internet DOE Core Certificate. The proctor's name will placed on the certificate for accountability. Each certificate will be serialized by SES, Inc. for easy verification by DOE Facility. Please note that during normal work hours Mon-Sunday 0800-1630 hrs test results and DOE Core Certificate emailing will take place in approximately four hours.

Information required for Proctor:

Full Name:

Company working for:

Credentials (NRRPT, CHP, Company Recruiter/Notary Public):

Mailing Address:

Email Address (required):

Phone number:

Proctor will be given an ID number. For test result verification the following will be required:

1) Email from Proctor's email for student test results and verification of students social security number with picture identification.
2) Proctor's confidential ID number.
3) Student results verified by database.

For more info contact:

Shawnee Environmental Services, Inc. (SES, Inc.)
116 Broadway Street
Seaman, Ohio 45679
(937) 572-9704/9706
admin@shawneerct.com

1.02.01- Identify the commonly used unit systems of Measurement and the base units for mass, length and time in each system:

English system SI system

Length----Foot--------------------Meter

Mass------Pound-------------------Kilogram

Time------Second------------------Second

1.02.02---Identify the values and abbreviations for SI prefixes:

SI Prefixes

mega-----10e6--------M

kilo-----10E3--------k

hecto----10E2--------h (have not used)

deka-----10E1--------da (have not used)

deci-----10E-1-------d

centi----10E-2-------c

milli----10E-3-------m

micro----10E-6-------u

nano-----10E-9-------n

pico-----10E-12------p

Metric Subsystems

CGS MKS

Length-----centimeter--------meter

Mass-------gram--------------kilogram

Time-------second------------second

1.02.03-Given a measurement and the appropriate conversion factors or conversion factor table, convert the measurement to the specified units.

See chart in RCT Core Module 2 Study Guide

1.02.04-Using the formula provided, convert a given temperature measurement to specified units.

F to C= C= (F-32/1.8)

C to F= F= (C) + 32

C to K= K= C + 273.15

1.03.01-Define the following terms as they relate to physics:

Work- A force acting through a distance.

Force- Is any action on an object that can cause the object to change speed or direction.

Energy- Is defined as the ability to do work.

1.03.02- Identify and describe four forms of energy:

Kinetic energy----Energy of motion an object possesses.

Potential energy—Indicates how much energy is stored as a result of the position of an object.

Thermal energy----Or heat, describes the energy that result from the random motion of molecules.

Chemical energy---The energy that is derived from atomic an molecules interactions in which new substances are produced.

1.03.03- State the Law of Conservation of Energy:

The total amount of energy in a closed system remains Unchanged, it can be converted from one form to another:

1.03.04- Distinguish between a solid, a liquid, and a gas in terms of shape and volume:

State	Shape	Volume
Solid	Definite	Definite
Liquid	Indefinite	Definite
Gas	Indefinite	Indefinite

1.03.05- Identify the basic structure of the atom, including the Characteristics of subatomic particles:

The Bohr Model

Atom--------The fundamental building block of matter.

Nucleus-----The central core and it contains protons and neutrons (Nuclear forces hold the nucleus together).

Protons-----Positively charged (+1)
Each element is determined by the number of protons in it's nucleus.

Neutrons----Neutrally charged (0)
The number of neutrons determine the isotope (are atoms which have the same number of protons, but different number of neutrons) an element:

Does not affect the chemical properties of element.

Electrons---Negatively charged (-1)
-Small mass-1/1840 of proton
-The number of electron is normally equal to number protons.
-The number of electrons in the outermost shell determines the chemical behavior or properties of the atom.

1.03.06- Define the following terms:

Atomic Number-------- The number to protons in the nucleus of an element.
It is represented by the symbol Z.

neutrons in the nucleus.
It is represent by the symbol A.

Atomic Mass---------- The actual mass of an atom of a Particular isotope expressed in Atomic Mass Units (AMUs).

Atomic Weight-------- The weighted average of the isotopic of an element, based on the percent abundance of it's naturally occurring isotopes.

1.03.07- Identify what each symbol represents in the $^{A}_{z}X$ notation:

A------Mass number (Number of protons + neutrons)

Z------Atomic number (Number of protons)

X------Symbol for element

1.03.08- State the mode of arrangement of the elements in the Periodic Table:

Is an arrangement of the elements in order of increasing atomic number.

Periodic Law- The properties of the elements are repetitive or recurring functions of their atomic numbers.

1.03.09- Identify periods and groups in the Periodic Table in terms or their layout.

Periods—Rows or horizontal sections (increasing Neutron Number).

Groups or Families – Column or vertical sections (increasing Proton number)

Since the number of electrons is equal to the number of protons, the structure of the Periodic Table directly relates to the number and arrangement of electrons in the atom.

1.03.10—Define the terms as they relate to atomic structure:

Valance Shell----The highest occupied energy level in a ground state atom.

The number of electrons in the valence shell determines the chemical properties or behavior of the atom.

Valence Electron-The electrons contained in the valance shell.

1.04.01-Identify the definitions of the following terms:

Nucleon -----Neutrons and Protons in the nucleus(particles)

Nuclide------A species of atom characterized by the constitution of it's nucleus, which is specified it's atomic mass and atomic number or by it's number or protons, number of neutrons and energy content.

Isotope------Nuclides which have the same number of protons but different number of neutrons.

1.04.02-Identify the basic principles or the mass-energy equivalence concept:

E=mc(square)-----expresses the equivalence of mass and energy Meaning that mass may be transformed to Energy and vice versa (mass-energy).

Mass energy------Implies that mass and energy are Interchangeable.

Pair Annihilation-----Two particles with mass, a positron and An electron, collide and are transformed Into two rays of electromagnetic energy An example of mass to energy conversion Or mass-energy.

1.04.03-Identify the definitions of the following terms:

Mass Defect-----The difference between the total mass of an Atom and the sum of the masses of the Individual protons and neutrons.

Binding Energy-The energy that binds the nucleus together is the energy equivalent of mass defect.

Binding Energy per nucleon- The total binding energy of a Nuclei's

Binding Energy-----The energy that binds the nucleus together is the energy equivalent of mass defect.

Binding energy per nucleon- The total binding energy of a Nuclides is divided by the total Number of nucleons in the nucleus This represents the average energy Must be supplied in order to Remove a nucleon from the nucleus.

1.04.04---Identify the definitions of the following terms:

Fission-----The splitting of the nucleus into at least two smaller nuclei with an accompanying. release of energy.
The new element is unstable (N/P too high).

Critical energy for fission- The energy required to drive the nucleus to the point of separation.

Criticality-The condition in which the neutrons produced by Fission are equal to the number of neutrons in In the previous generation.

Fusion------The act of combining or fusing two or more atomic Nuclei:
Fusion builds atoms.

1.05.01---Identify the following four sources of natural background radiation including the origin, radionuclides, variables and contribution to exposure:

Terrestrial radiation-In soil (uranium and thorium) in water (K-40)- dependent on location --- exposure = 28mrem.

Cosmic----- Primary and secondary rays- depends on altitude exposure = 27 mrem.

Internal Emitters - Soil\water, food cycle-K40 most abundant in man-exposure = 39 mrem.

Inhaled Radionuclides-Uranium, thorium and radon-dependent on location exposure = 200 mrem.

1.05.02---Identify the following four sources of artificially produced radiation and the magnitude of dose received from each.

Nuclear fallout-debris which settles to the earth as the result of nuclear blast => Exposure= <1 mrem.

Medical exposures-From X-ray => Exposure is 53 mrem.

Consumer products-TV, watches and etc. => Exposure is 10 mrem.

Nuclear Facilities- Power plants => Exposure is <1 mrem.

1.06.01---Identify how the neutron to proton ratio is related to nuclear stability:

Nuclear stability is governed by the particular combination and arrangement of neutrons to protons in in a given nucleus.

Nuclear force is independent of charge.

As elements increase in Z numbers the neutron to proton ration gradually increases.

At the high atomic number there are no completely stable nuclei.

1.06.02---Identify the definition of the following terms:

Radioactivity-The property of certain nuclides to spontaneously emit radiation (the emission of particles or energy from the nucleus).

Radioactive decay-The process by which a nucleus spontaneously disintegrates by one or more discrete energy steps until a stable is reached.

Parent- The nucleus before the decay

Daughter-The nucleus after decay.

Naturally radioactive- Occur in nature.

Artificially Radioactive- Man made reaction.

1.06.03---Identify the characteristics of Alpha, Beta and Gamma radiations

Alpha- Particulate radiations (from the nucleus - consist of Two protons and two neutrons)
-Only relatively heavy radioactive nuclides decay by alpha emission.
-Least penetrating
-Stopped by paper

Beta- Particulate radiations (from the nucleus)
-charge of -1 and mass of 5.49E-4 amu
-Nuclide that has an excess number of neutrons will decay by beta emission.

Gamma- From an excited nuclei (still electrically neutral)
-Comes from the nucleus

-Electromagnetic radiation called photons or x- ray

-Lead used to stop gamma.

1.06.04--- Given simple equations identify the following radioactive decay modes:

Heavy radionuclides generally decay by alpha and beta - Emission.

Lighter radionuclides (Activation and fission products) Decay by beta +(positron) or electron capture (K-capture)

Know Equation Not Given

Alpha decay - $^{a}_{z}x \Rightarrow {}^{a-4}_{z-2}Y + {}^{4}_{2}$ alpha

Beta decay - $^{a}_{z}x \Rightarrow {}^{a}_{z+1}Y$ +beta - minus + antineutrino (are neutral Uncharged particles)

-Changing a neutron to a proton

-Excess number of neutron

Positron Decay- Low n:p ratio or too many protons

- Changes a proton into a neutron

$^{A}_{z}X = ^{a}_{z-1}Y$ + Beta +(positron) + neutrino
(neutral uncharged particles)

Electron Capture- Low n:p ratio or too many protons

-Changes a proton into a neutron by capturing a electron from the K-shell (this mode of decay is called K-capture)
-Characteristic X-ray are formed
$^{A}_{Z}X$ + electron = $^{a}_{z-1}Y$ + neutron

1.06.05---Identify two aspects associated with the decay of radioactive nuclide:

Pattern of decay

Modes of decay

Types of emissions involved

Energies of the emissions involved

Rate of decay

1.06.06---Identify differences between natural and artificial radioactivity:

Natural-occurs in nature

Artificial-Man-made reactions

1.06.07----Identify why fission products are unstable:

The nuclear fragments. Directly resulting from fission have too Large of a proportion of neutrons to protons for stability:

Predicting Mode Of Decay

Nuclides below the line of stability will usually undergo Beta-minus decay

Nuclides above the line of stability will usually undergo Positron decay of electron capture.

1.06.08---Identify the three naturally-occurring radioactive families and the end product of each:

Uranium
Thorium **All go to Lead (Pb)**
Actinium

Artificial Series
Neptunium series (Was in nature at one time)

1.06.09---Given nuclide, locate its block on the Chart of Nuclides and identify the following:

Atomic number, atomic mass, natural percent abundance,
Stability, half-life, and types and energies of radioactive

(Study the Chart of the Nuclides)

1.06.10---Given the Chart of Nuclides, trace the decay of a radioactive nuclide and identify the stable end-product.

(Study the Chart of the Nuclides)

Chart of Nuclides

In arranging the nuclides in chart form, the number of Neutrons (N) is plotted horizontal on the x-axis Against the number of protons (atomic number, z) On the y-axis (vertical)

1.06.11---Identify the definition of the following units:

Curie-It was based on the disintegrations per second Occurring in the quantity of radon gas in equilibrium With on gram of radium

-About 37 billion atoms dsp (3.7E10) or 2.22E12 dpm

Curie--------Ci--------3.7E10 dps------2.22E12 dpm

Millicurie----mCi----3.7E7-----2.22E9 dpm

Microcurie---uCi----3.7E4 dps----2.22E6 dpm

Nanocurie----nCi----3.7E1 dps----2.22E3 dpm

Picocurie----pCi----3.7E-2dps----2.22 dpm

Becquerel Superunits

Becquerel----Bq----1 dps----60 dpm

1.06.12---Identify the definition of specific activity:

The activity per unit mass of radioactive substance and is

Reported in units such as curies per gram (Ci/g)

1.06.13---Identify the definition of half-life:

The time that is required for the activity present to be reduced to one-half.

1.06.14---Calculate activity using the formula for radioactive decay:

$A_{final} = A_{original} \times e^{-lamda(t)}$;lamda=.693/half-life or $A_{final} = A_{original} \times (1/2)^{n}$;n = time/half-life.

1.06.15A--Identify the definition of the following:

Exposure---Is a measure of the ability of photons (x and gamma) To produce ionization in air:

The unit of exposure is roentgen (R) which is 2.58E-4 Coulombs/kg of air.

Absorbed Dose- Units of dose measure the amount of radiation energy Absorbed or deposited per unit of mass

Units

The Rad (Radiation Absorbed Dose) old CGS unit-definition is any radiation of 100 ergs of energy in one gram of any material.

The Gray-SI derived unit-equivalent to the deposition of one joule of Energy per kilogram=100 rad.

Quality Factor (Q) used to relate the absorbed dose of various kinds of radiation to the biological damage caused to the exposed tissue.

----Converts the absorbed dose (Rad or Gray) to a unit of dose equivalence.

Formula------H = DQ

H = dose equivalent (Rem of Sievert)

D = absorbed dose (Rad or Gray)

Q = Quality factor

Quality Factors

X-Rays, Gamma Rays, Positrons, Electrons (Including Beta particles)

Slow Neutron ---3
Fast Neutron and protons--10
Alpha particles-----------20

Dose Equivalent (H) a measurement of the dose equivalent by multiplying the absorbed dose by the quality factor.

Rem- Acronym for Roentgen Equivalent Man
---Rad x Q
Sievert-SI derived unit
---Gray x Q
--- = 100 rem

1.07.01---Identify the definitions of the following terms:

Ionization---Any process which results in the removal of an electron from an electrically neutral atom.

Excitation---Any process that adds enough energy to an electron of an atom so that it occupies a higher energy state than its lowest bound energy state (ground state)

-Atom is still electrically neutral

Bremsstrahlung--Is the radioactive energy loss of moving charged particles as they interact with the matter through which they are moving.

-X-ray are emitted

-Called braking radiation

-Is enhanced for high z materials and high energy electrons

1.07.02---Identify the definitions of the following terms:

Specific ionization is the number of ion pairs formed by the particle per path length.

Linear energy transfer (LET)--Is the average energy locally deposited in an absorber resulting from a charged particle per unit distance of travel:
LET-less than or equal to stopping power

Stopping power-Of an absorber is its ability to remove energy from a beam of charged particles:

LET- is less than or equal to stopping power.

Range--Of a particle in an absorber is the average depth of penetration of the charged particle into the absorber before it loses all its kinetic energy and stops.

Only has meaning for charged particles whose energy is kinetic energy, which is lost continuously along their path.

W- Value---The average amount of energy needed to create an ion pair in a given medium.

1.07.03---Identify the two major mechanisms of energy transfer for alpha particulate radiation:

Ionization
Excitation

1.07.04---Identify the three major mechanisms of energy transfer for beta particulate radiation:

Ionization
Excitation
Bremsstrahlung

1.07.05---Identify the three major mechanisms by which gamma photon radiation interacts with matter:

Photoelectric Effect--Is an all or none energy loss, the gamma ray impacts all of its energy to an orbital electron of some atom:(takes place near the nucleus)

Compton Scattering---The gamma ray interacts with an orbital electron of some atom and only part of the energy is transferred to the electron (knocking electron away from the atom) and the gamma ray continues on with less energy:
(Gamma and Electron)

- Take place mostly on valence electron
- Medium energy photon

Pair Production--A gamma photon simply disappears in the vicinity charged and one positively charged:

- Has to possesses greater the 1.022 MeV of Energy.

- Two gammas of .511 MeV each arise

At the site of the annihilation (the 2 electron annihilate each other) The fate of the annihilation gammas is either photoelectric absorption or Compton scattering followed by photoelectric absorption

- High energies

1.07.06---Identify the four main categories of neutrons as they are classified by kinetic energy:

Thermal---- ~0.025 eV to <0.5 eV

Intermediate-----0.5 eV to 100 KeV

Fast-------------100KeV to 20 MeV

Relativistic----->20MeV

1.07.07---Identify three possible results of neutron capture for slow neutrons:

Gamma

Charged Particles

Fission

1.07.08---Identify elastic and inelastic scattering interactions for fast neutrons:

Elastic scattering-occurs when a neutron strikes a nucleus of approximately the same mass as that of the neutron. The neutron transfers all of its kinetic energy to the nucleus knocking it away from the electrons.

---No gamma is given off

----Causes ionization and excitation

Inelastic scattering Occurs when a neutron strikes a large nucleus, the neutron penetrates the nucleus, transfers energy to the nucleon inside, and then exits with a small decrease in energy. The nucleus is left in an excited state emitting gamma radiation (which can cause ionization)

1.07.09---Identify the characteristics of materials best suited to shield.

Alpha-----Paper

Beta-----low Z and low-density material (rubber aluminum, plastic)
High Z will cause Bremsstrahlung productions.

Neutron---Fast-Hydrogenous material to slow neutron down (oil, Plastic, and water)
Slow--boron or cadmium

1.08.01---Identify the function of the following cell structures:

Cell Membrane--It helps to regulate the concentration of water, Salts, and organice matter which form the interior Environment matter, which form the interior Environment of the cell:

Cytoplasm---Is a jelly like substance in which the nucleus is

Suspended:

Mitochondria---The power plants of both plant and animal cells Supplies the energy for all the activities of the Cell:

Lysosomes---Contains the digestive enzymes that break down large Molecules:

Nucleus-----Directs cellular activity and contains the hereditary Factors:

DNA---------Material making up the chromosomes and serves an the master Blueprint for the cell:

Chromosomes-Consist of highly convoluted supercoils of DNA and Associated protein:

1.08.02---Identify effects of radiation on cell structures:

Cell membrane-----3k to 5k Rads to rupture the cell membrane.

Cytoplasm---------Radiation effects are negligible compared to Observed effects on structures, which are Suspended within it.

Mitochondria------Few thousand rad to disrupt their function:

Lysosome----------500 to 1k Rads will rupture lysosome

Nucleus-----------Most sensitive part of the cell (effect DNA 1st)

1.08.03---Identify the law of Bergonie and Tribondeau:

The radiosensitivity of a tissue is directly proportional to its Reproductive capacity and inversely proportional to its degree of Differentiation:

10.08.04---Identify factors which affect the radiosensitivity of cells

Cells that have a high division rate, high metabolic rate, non-Specialized type, and are well nourished.

1.08.05---Give a list of types of cells; identify which are most or least radiosensitive:

Radiosensitive (Cell that are damaged easily)

Germinal (reproductive) Cells

Hematopoietic (Blood forming) tissues, red bone marrow, spleen lymph

, epithelium of the skin.

Radioresistant (do not damage easily)

Bone

Liver

Muscle

Nervous tissue

1.08.06---Identify primary and secondary reactions on cells produced by ionizing radiation:

Primary- If the molecules breaks up the fragment are called free radicals and ions, and are not chemically stable (they are electrically neutral structures with one unpaid electron (water=H + OH)
H2o=H+OH

Secondary--They can combine and produce hydrogen peroxide (H2 O2) Which is a chemical poison and is the most harmful free radical product.

1.08.07---Identify the following definitions and give examples of each:

Stochastic effect--Are those in which the probability within a population of the effect occurring increases with dose:

---Without threshold

---Cancer and genetic are examples

Non-Stochastic--Are those in which the severity of the effect varies with the dose:

---With Threshold

---Cataracts, skin ulcerations (burns) deletion of blood-forming cells and impairment of fertility:

1.08.08---Identify the LD 50/30 value for humans:
The dose of radiation expected to cause death within 30 days to 50% of those exposed without medical treatment (300 to 500 Rads or usually stated as 450 Rads)

1.08.09---Identify the possible somatic effects of chronic exposure to radiation:

Chronic radiation exposure-involve a low dose over a relatively long period of time:

---Cancer, Cataracts (600 to 900 R), life span shorten

---Observed if dose is greater than 10 Rads

1.08.10---Distinguish between the three types of the acute radiation syndrome, and identify the exposure levels and the symptoms associated with each:

Syndrome

Hematopoietic system---200 to 1,000 rad

Gastrointestinal tact---1k to 5k rad---includes loss of weight in Illness stage.

Central nervous system--over 5k rad---death result from respiratory failure or brain edema.

Progress through four stages:

Prodromal stage---nausea, vomiting, diarrhea, anorexic (loss of appetite) and fatigue.

Latent Phase---Between the prodromal stage and the onset of later Stages.

Illness---Same as prodromal stage+ ulcerations about the mouth, fever and etc.

Recovery or death - above 1K Rads death is probably certain (usually at 600 Rads)

1.08.11---Identify risks of radiation exposure to the developing embryo and fetus:

Most of the major organs in humans are developed during the period from the second to the sixth week post conception.

Doses as low as 25 Rad have shown to be effective in producing development changes.

A dose of 400 to 600 rad during the first trimester or pregnancy Is sufficient to cause fetal death and abortion:

1.08.12---Distinguish between the term somatic and heritable (or genetic) as they apply to biological effects:

Somatic Effect individual, not passed on:

Heritable or genetic- There is no threshold for genetic Mutation resulting from exposure to Ionizing radiation:

1.09.01---Identify the role of advisory agencies in the development of recommendations for radiological control

ICRU--Formed in 1925, in 1928 adopted the definition of Roentgen:

ICRP--Adopted 1st set of Radiation Protection Recommendation

NCRP--Formed in 1929 and served as the basis fro protection during the Manhattan Project
-Provides recommendations to other agencies now (NCRP report)

1.09.02---Identify the role of regulatory agencies in the development of standards and regulations for radiological control:

AEC(Atomic Energy Act)--In 1954 was given the responsibility of regulating the atomic energy industry

NRC--Took over the licensing and regulatory functions:

ERDA--Assumed responsibility of energy research and development:

ERDA was replaced in 1977 by the US Department of Energy (DOE) (Radiation protection- Radiological control manual)

1.09.03---Identify the purpose and scope of the DOE Radiological Control Manual:

There should not be any occupational exposure of workers to ionizing radiation without the expectation of and overall benefit from the activity causing the exposure:

The Radiological Control Manual is the main document for control of work place:

1.09.04---Identify the definitions of the terms “shall” and “should” as used in DOE documentation:

Shall---Identifies those elements and requirements that have been considered and found by DOE to by mandatory unless prior approval of an alternative approach is obtained from DOE:

Should---Means the contractor has the responsibility of either following the provision or demonstrating technical equivalency by an alternative solution:

1.10.01---Describe the assumption on which the current ALARA philosophy is based:

ALARA- As Low As Reasonable Achievable:

ALARA philosophy-The cautious assumption that a proportional relationship exits between dose and effect with a non-threshold concept.

1.10.02---Identify the ALARA philosophy for collective personnel exposure and individual exposure:

Individual dose- Is defined as the total dose received by a radiological worker due to occupational exposure:

Collective dose- Is defined as the total individual dosed in a group or a population:

The DOE would like to see an overall reduction in both individual and in both collective doses used as the basis for determining the effectiveness of a facilities ALARA program

1.10.03---Identify the scope of an effective radiological ALARA program:

The ALARA program must be incorporated in everyday, routine function as well as non-routine, higher risk tasks:

The risk associated with projected radiation exposures should be small when compared to the benefit derived:

1.10.04---Identify the purposes for conducting pre-job and\or post-job AlARA reviews:

Pre-Job ALARA- For every task involving radiological work, sufficient radiation protection controls should by specified in procedures and work plans to define and meet requirements:

-Applicable ALARA practices shall be factored into the plans and procedures:

Pre-Job Briefing- The technician will identify the effective dose reduction measures for the conditions:

-Procedures will be reviewed:
-Worker qualifications verified
-Emergency procedures will be discussed

Post-Job ALARA-Unusual exposure events are investigated
-Ensure the overall effectiveness of job planning and implementation:

Post-Job Briefing-Gives the RCT and the workers the opportunity to critique the work performance:

1.10.05---Identify RCT responsibilities for ALARA implementation:

If the RCT notices the worker not following good radiological work practices on the spot corrections should be made:

Stop Work Authority Exercise:
1-Inadequate radiological control:

2-Radiological controls not being implemented

3-Radiological controls hold point not being satisfied:

1.11.01---Identify the four basic methods for minimizing personnel external exposure:

1-Reduce the amount of source material:

2-Reduce the amount of time of exposure to the source of radiation:

3-Increase the distance from the source of radiation:

4-Reduce the radiation intensity by using shielding:

1.11.02---Using the exposure Rate=6cen equation, calculate the gamma exposure rate specific radionuclides:

Exposure Rate:(in feet)R/hr= 6CEN;(in meters)R/hr= .5CEN
C=source activity in Ci

E=Gamma energy in MeV[(Gamma 1x %) + (Gamma 2 x %) + etc,]

N=Number of gammas per disintegration (photon yield)

1.11.03---Identify "source reduction" techniques for minimizing personnel external exposures:

1-Allow natural decay to reduce source strength

2-Decon the equipment or material

3-Reduce the source material in the system by flushing equipment

4-Discharge or remove the resin or filtering media

5-Move the radioactive source

1.11.04---Identify "time-saving" techniques for minimizing personnel external exposures:

1-Pre-Job briefing

2-Review job history files

3-Pre-stage all tools and equipment

4-Pre-assemble equipment and tools outside the area

5-Use time limiting devices

6-Use communication devices

7-Use a team of workers instead of one individual

8-Use experienced personnel

1.11.05---Using the stay time equation, calculate an individual's allowable dose equivalent or stay time:

(Not Given Know Equation)

X=(R/t)
R/t=dose rate
T= length of time exposed

Stay Time=H(allowable) minus H(received)/ dose equivalent rate

Have to use Q factor on dose equivalent

1.11.06---Identify "distance to radiation sources" techniques for minimizing personnel external exposures:

1. Remote handling tools/remote control devices
2. Remote observation by cameras or indicators
3. Move work to another location
4. Maximize the distance
5. Posting of areas
6. Extendable instruments

1.11.07---Using the point source equation (inverse square law), calculate the exposure rate or distance for a point source of radiation:

(Know Equation Not Given)

$$I_1 \times d^2 = I_2 \times d^2$$

1.11.08---Using the line source equation, calculate the exposure rate or distance for a line source or radiation:

(Know Equation Not Given)

$I_1 \times d_1 = I_2 \times d_2$

Valid to a point that is L/2 Transition pt, beyond which the point source formula should be used:

1.11.09---Identify how exposure rate varies depending on the distance from a surface (plane) source of radiation:

When the distance to the plane source is small compared to the longest dimension, then the exposure rate falls off a little slower than L/d

As the distance from the plane source increases, then the exposure rate drops off at a rate approaching L/d squared.

1.11.10---Identify the definition of "mass attenuation coefficient" and "linear"

Linear attenuation coefficient is the probability of a photon interaction per path Length: Has units of length (exponent of -1)

Mass attenuation coefficient is the probability of a photon interaction per path length: Has units of length (exponent of 1)

1.11.11---Identify the definition of "density thickness"

Is a value equals to the product of the density of the absorbing material and its thickness [in units or mg/cm (squared)

1.11.12---Identify the density-thickness values, in mg/cm (squared), for the skin, lens of the eye and the whole body:

Skin-----7 mg/cm (squared)

Lens of eye-300 mg/cm (squared)

Whole Body-1000 mg/cm (squared)

1.11.13---Calculate shielding thickness or exposures rates for gamma/x-ray radiation using the equations:

(Equations not given, KNOW equation)

One half-value layer-as the amount of shielding material required to reduce the radiation intensity to one-half of the unshielded value:

$I_{shielded} = I_{unshielded} \times (1/2)^n$;exponent n = number of HVLs

HVL= shield thickness in cm/HVL thickness in cm

One tenth-value layer-as the amount of shielding material required to reduce the radiation intensity to one-tenth of the unshielded value:

$I_{shielded} = I_{unshielded} \times (1/10)^n$; exponent n = number of TVLs

TVL = Shield thickness in cm / TVL thickness in cm

1.12.01---Identify four ways in which radioactive materials can enter the body:

1. Inhalation (Material enter the body in the air that is breathed)
2. Ingestion (Materials enter the body through the mouth)
3. Absorption (Material enters the body through intact skin)
4. Entry through wounds
    1. Penetration- Materials enter through existing wounds:
    2. Injection- Materials enter through wounds incurred on the job;

1.12.02---Given a pathway for radioactive materials into the body, Identify method to prevent or minimize entry by that pathway:

1. Inhalation- Assessment of conditions, use of engineering controls, respiratory protection equipment:
2. Ingestion- Proper radiological controls and work practices:
3. Absorption- Assessment of conditions and protective clothing:
4. Entry through wounds- Not allowing contamination near a wound by work restriction or proper radiological controls if an injury occurs in a contaminated area:

1.12.03---Identify the definition and distinguish between the terms "Annual limit on Intake" (ALI) and "derived Air Concentration" (DAC).

Annual Limit on Intake- The quantity of a single radionuclide, which, if inhaled or ingested in one year, would irradiate a person, represented by reference man to limiting value for control of the workplace:

Derived Air Concentration- The quantity obtained by dividing the ALI for any given radionuclide by the volume of air breathed by an average worker during a working year:

1.12.04---Identify the basis for determining Annual Limit on Intake (ALI)

1. The metabolic process for the isotopes
2. The annual dose limit

3. Reference man (metabolic process)

1.12.05---Identify the definition of "reference man"

Defines the physiological makeup of an average man in terms of factors required for dose calculations and includes such items as height and other dimensions, mass, size and mass of organs:

1.12.06---Identify a method of using DACS to minimize internal exposure potential:

1. Posting of airborne radioactivity areas
2. Minimizing the stay of workers in airborne areas
3. Respiratory protection equipment

1.12.07---Identify three factors that govern the behavior of radioactive materials in the body:

1.Chemical form- Solubility
2.Location-------Pathways
3.Body's need ---Intake and incorporation vs. elimination.

1.12.08---Identify the two natural mechanisms which reduce the quantity radionuclides in the body:

1. Normal Biological Elimination Materials are eliminated through the normal biological elimination processes of exhalation, perspiration urination and defecation:

    (1) Biological half-life the time required to reduce amount of material in the body to one-half of its original value (Independent of the physical or radiological half-life)

2. Radioactive Decay- The amount of time required for one half of the material in the body to decay (called radiological or physical half-life)

1.12.09---Identify the relationship between the physical, biological and effective half-lives:

Physical or radiological half life- the amount of time required for One half of the material in the body to decay:

Biological half life-The time required to reduce the amount of material in the body one-half of its original valve:

Effective half life- The combined processes of biological elimination and physical decay results in the removal of radioactive materials at a faster rate than the individual reduction rate produced by either method:

1.12.10---Given the physical and biological half lives, calculate the effective half-life:

Formula not given - Know the formula; hint: tit(times) over prostate(plus)

$T_{effective\ ½\ life} = T_{biological\ ½\ life}\ x\ T_{physical\ ½\ life} /\ T_{biological\ ½\ life} + T_{physical\ ½\ life}$

1.12.11---Given a method used by medical personnel in increase the elimination rate of radioactive materials from the body, identify how and why that method works:

Blocking agent- Saturates the metabolic processes in a specific tissue with the stable element and reduces uptake of the radioactive forms of the element:

Diluting agent- A compound that includes a stable form of the nuclide of concern. This will reduce the body incorporating radioactive atoms:

Mobilizing agent- A compound that increases the natural turnover process, thus releasing some forms of radioisotopes from body tissues:

Chelating agent- A compound that acts on insoluble compounds to form a soluble complex ion, which can then be removed through the kidneys:

1.13.01---Identify the three fundamental laws associated with electrical charges:

1. Opposite electrical charges of equal value cancel each Other out:
2. Opposite electrical charges attract each other:
2. Like electrical charges repel each other:

1.13.02---Identify the definition of current, voltage and resistance and their respective units:

Current- The movement, or flow, of electrons past a given point in a circuit:

-Measured in units called amperes:

Voltage- The electrical potential difference that causes electrons to flow in a circuit:

-Measured in units called volts:

Resistance- The electrical quantity that opposes electron flow in a circuit:

-Measured in units called ohms:

1.13.03---Select the function of the detector and readout circuitry components in a radiation measurement system:

Types of detectors

Ionization- The incident radiation creates ion pairs in the detector:

- GM tubes, GeLi detector used in multichannel analyzer:

Excitation_ The incident radiation excites the atom of the detector material:

-TLD, and scintillation detectors:

Chemical- The incident radiation caused ionization or excitation of detector media thereby causing chemical changes, which can be

-Film badges:

1.13.03---Select the function of the detector and readout circuitry components in a radiation measurement system:

Readout Circuitry- Measures and analyzes the produced effect and provides a usable output indication:

1.13.04---Identify the parameters that affect the number of ion pairs collected in a gas-filled detector:

1-Type of radiation
2-Energy of the radiation
3-Quantity of radiation
4-Detector size
5-Type of detector size
6-Type of detector gas
7-Detector gas pressure
8-Voltage potential across the electrodes
9-Effect of voltage potential on the detector process

1.13.05---Given a graph of the gas amplification curve, identify the regions of the curve:

Know: Rest In Peace Little Gray Cat

1.13.06---Identify the characteristics of a detector operated in each of the useful regions of the gas amplifications curve:

Ion Chamber Detectors- All ions are collected before they can recombine:

-Output current will be relatively independent of small fluctuations in the power supply
-The ion chamber response is directly proportional to the dose rate:
-Yields the true exposure rate:

Proportional Detectors-The avalanche caused by a single ionization results in single very large pulse:

1.13.07---Identify the definition of the following terms:

Resolving time- The time from the initial measured pulse until another pulse can be measured by the electronics:

Dead Time------ Is time from the initial pulse until another pulse can be produced the detector:

Recovery Time-- The time from the initial full size pulse to the next full size pulse produced by the detector:

1.13.08---Identify the methods employed with gas-filled detectors to discriminate between various types of radiation and various radiation energies:

Discrimination

1. Physical discrimination:
   Shielding-The most common method of discriminating:
2. Detector gas fill- Each type of radiation has a specific ionization factor in a particular gas:
3. Electronic discrimination- Analyzing pulse heights is the primary method of electronic discrimination:

1.13.09---Identify how a scintillation detector and associated components operate to detect and measure:

1. Scintillation detector- Measure radiation by analyzing the effects of the excitation of the detector material by the incident radiation.
2. Scintillation- Is the process by which a material emits light When excited.

Scintillation Detector Components:
The phosphor or fluor-organic crystals, organic liquids, inorganic crystals, and inorganic powders:

The photomultiplier- Is to detect the scintillations and to provide an output signal proportional to the amount of scintillations:

Construction

Photocathode- Is to convert the light photons to electrons (Photoelectrons)

Dynode Assembly- Used to amplify the signal
- Some time called Photo-multiplier

Anode- Collect the electrons and generates an output pulse.

Voltage divider network- Splits the high voltage supply into the various potentials required by the dynodes:

Shell- Supports the other component and seals the tube from stray light And seals the tube from stray light and stray electric/magnetic Fields:

1.13.10---Identify how neutron detectors detect neutrons and provide an electrical signal:

Slow Neutron Detection:

Boron Activation- Neutrons strike an atom of Boron-10; an alpha particle is emitted. This alpha particle then produces ionization, which can be measured.

Fission Chambers- Neutron will cause an atom of U-235 to fission, with the two fission fragments produced having a high kinetic energy and causing ionization to the material they pass through:

Scintillation- Incorporating lithium-6 in the crystal:

Activation Foils- Have the ability to absorb neutrons of a specific energy and become radioactive through the radioactive capture process:

Fast Neutron Detection

Proton Recoil (Ion Chamber/Proportional)- When fast neutrons undergo elastic scatterings with hydrogen atoms, they frequently strike the hydrogen atom with enough force to knock the proton nucleus away from the orbiting electron:

1.13.11---Identify the principles of detection, advantages and disadvantages of a GeLi detector and an HPGe detector:

In a semiconductor electrons move from the valance to conduction leaving holes, which are filled by other electrons (this is called electron-hole pairs) this is used to measure radiation in an ion chamber;

GeLi Systems

Advantages-High resolution
-Short response time

Disadvantages-can only be used for gamma photon detection
-This system is required to be kept cool;

HPGe's Systems

Advantages-more portable:
-Can be allowed to rise to room temperature, and then be returned to and stabilized at liquid nitrogen temperature range.

Disadvantages-Tend to be fairly expensive:

INSTRUCTIONS FOR USING CONVERSION FACTOR TABLES

The tables that follow include conversion factors that are useful to the RCT. They are useful in making a single conversion from one unit to another by using the guide arrows at the top of the page in accordance with the direction of the conversion. However, when using the tables to develop equivalent fractions for use in unit analysis equations, a better understanding of how to read the conversion factors given in the table is required.

The conversions in the table have been arranged by section in the order of fundamental units, followed by derived units:

Length
Mass
Time
Area
Volume
Density
Radiological
Energy
Fission
Miscellaneous (Temperature, etc.)

The easiest way to read a conversion from the table is done as follows. Reading *left to right,* "one (1) of the units in the left column is equal to the number in the center column of the unit in the right column." For example, look at the first conversion listed under **Length**. This conversion would be read from left to right as "1 angstrom is equal to E-8 centimeters," or

$$1\text{Å} = 10^{-8}\ \textit{centimeters} \Rightarrow \frac{1\ \text{Å}}{10^{-8}\ \textit{centimeters}}$$

Another conversion would be read from left to right as "1 millimeter (mm) is equal to 1E-1 centimeters," or *1 mm = 0.1 cm*. This method can be applied to any of the conversions listed in these tables when reading *left to right*.

If reading *right to left*, the conversion should be read as "one (1) of the unit in the right column is equal to the inverse of (1 over) the number in the center column of the unit in the left column." For example, using the conversion shown previously, the conversion reading right to left would be "1 inch is equal to the inverse of 3.937E-5 (1/3.937E-5) micrometers," or

$$1\ \textit{inch} = \frac{1}{3.937E{-}5\ \mu m} = 2.54E4\ \mu m$$

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Length

angstroms (Å)	10^{-8}	cm
Å	10^{-10}	m
micrometer (µm)	10^{-3}	mm
µm	10^{-4}	cm
µm	10^{-6}	m
µm	3.937×10^{-5}	in.
mm	10^{-1}	cm
cm	0.3937	in.
cm	3.2808×10^{-2}	ft
cm	10^{-2}	m
m	39.370	in.
m	3.2808	ft
m	1.0936	yd
m	10^{-3}	km
m	6.2137×10^{-4}	miles
km	0.62137	miles
mils	10^{-3}	in.
mils	2.540×10^{-3}	cm
in.	10^{3}	mils
in.	2.5400	cm
ft	30.480	cm
rods	5.500	yd
miles	5280	ft
miles	1760	yd
miles	1.6094	km

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Mass

mg	10^{-3}	g
mg	3.527×10^{-5}	oz avdp
mg	1.543×10^{-2}	grains
g	3.527×10^{-2}	oz avdp
g	10^{-3}	kg
g	980.7	dynes
g	2.205×10^{-3}	lb
kg	2.205	lb
kg	0.0685	slugs
kg	9.807×10^{5}	dynes
lb	4.448×10^{5}	dynes
lb	453.592	g
lb	0.4536	kg
lb	16	oz avdp
lb	0.0311	slugs
dynes	1.020×10^{-3}	g
dynes	2.248×10^{-6}	lb
u (unified--^{12}C scale)	1.66043×10^{-27}	kg
amu (physical--^{16}0 scale)	1.65980×10^{-27}	kg
oz	28.35	g
oz	6.25×10^{-2}	lb

NOTE: Mass to energy conversions under miscellaneous.

Multiply # of	→→→→→	by	→→→→→	to obtain # of
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Time

days	86,400	sec
days	1440	min
days	24	hours
years	3.15576×10^{7}	sec
years	525,960	min
years	8766	hr
years	365.25	days

Area

barns	10^{-24}	cm^2
circular mils	7.854×10^{-7}	$in.^2$
cm^2	10^{24}	barns
cm^2	0.1550	$in.^2$
cm^2	1.076×10^{-3}	ft^2
cm^2	10^{-4}	m^2
ft^2	929.0	cm^2
ft^2	144	in^2
ft^2	9.290×10^{-2}	m^2
$in.^2$	6.452	cm^2
$in.^2$	6.944×10^{-3}	ft^2
$in.^2$	6.452×10^{-4}	m^2
m^2	1550	$in.^2$
m^2	10.76	ft^2
m^2	1.196	yd^2
m^2	3.861×10^{-7}	sq mi

DOE CORE TEST CONVERSION TABLE

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Volume

cm^3 (cc)	0.99997	ml
cm^3	6.1023×10^{-2}	$in.^3$
cm^3	10^{-6}	m^3
cm^3	9.9997×10^{-4}	liters
cm^3	3.5314×10^{-5}	ft^3
m^3	35.314	ft^3
m^3	2.642×10^2	gal
m^3	9.9997×10^2	liters
$in.^3$	16.387	cm^3
$in.^3$	5.787×10^{-4}	ft^3
$in.^3$	1.639×10^{-2}	liters
$in.^3$	4.329×10^{-3}	gal
ft^3	2.832×10^{-2}	m^3
ft^3	7.481	gal
ft^3	28.32	liters
ft^3	1728	$in.^3$
gal (U.S.)	231.0	$in.^3$
gal	0.13368	ft^3
liters	33.8147	fluid oz
liters	1.05671	quarts
liters	0.26418	gal
gm moles (gas)	22.4	liters (s.t.p.)

SHAWNEE ENVIRONMENTAL SERVICES, INC.

DOE CORE TEST CONVERSION TABLE

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Density

cm^3/g	1.602×10^{-2}	ft^3/lb
ft^3/lb	62.43	cm^3/g
g/cm^3	62.43	lb/ft^3
lb/ft^3	1.602×10^{-2}	g/cm^3
$lb/in.^3$	27.68	g/cm^3
lb/gal	0.1198	g/cm^3

Radiological Units

becquerel	2.703×10^{-11}	curies
curies	3.700×10^{10}	dis/sec
curies	2.220×10^{12}	dis/min
curies	10^{3}	millicuries
curies	10^{6}	microcuries
curies	10^{12}	picocuries
curies	10^{-3}	kilocuries
curies	3.700×10^{10}	becquerel
dis/min	4.505×10^{-10}	millicuries
dis/min	4.505×10^{-7}	microcuries
dis/sec	2.703×10^{-8}	millicuries
dis/sec	2.703×10^{-5}	microcuries
kilocuries	10^{3}	curies
microcuries	3.700×10^{4}	dis/sec
microcuries	2.220×10^{6}	dis/min
millicuries	3.700×10^{7}	dis/sec
millicuries	2.220×10^{9}	dis/min
R	2.58×10^{-4}	C/kg of air
R	1	esu/cm^3 of air (s.t.p.)
R	2.082×10^{9}	ion prs/cm^3 of air (s.t.p.)

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

	<u>Radiological Units</u> (continued)	
R	1.610×10^{12}	ion prs/g of air
R (33.7 eV/ion pr.)	7.02×10^{4}	MeV/cm^3 of air (s.t.p.)
R (33.7 eV/ion pr.)	5.43×10^{7}	MeV/g of air
R (33.7 eV/ion pr.)	86.9	ergs/g of air
R (33.7 eV/ion pr.)	2.08×10^{-6}	g-cal/g of air
R (33.7 eV/ion pr.)	≈98	ergs/g of soft tissue
rads	0.01	gray
rads	0.01	J/kg
rads	100	ergs/g
rads	8.071×10^{4}	MeV/cm^3 or air (s.t.p.)
rads	6.242×10^{7}	MeV/g
rads	10^{-5}	watt-sec/g
rads (33.7 eV/ion pr.)	2.39×10^{9}	ion prs/cm^3 of air (s.t.p.)
gray	100	rad
rem	0.01	sievert
sievert	100	rem
$\mu Ci/^3$ (µCi/ml)	2.22×10^{12}	dpm/m^3
$\mu Ci/cm^3$	2.22×10^{9}	dpm/liter
dpm/m^3	0.4505	pCi/m^3
	<u>Energy</u>	
Btu	1.0548×10^{3}	joules (absolute)
Btu	0.25198	kg-cal
Btu	1.0548×10^{10}	ergs
Btu	2.930×10^{-4}	kW-hr
Btu/lb	0.556	g-cal/g
eV	1.6021×10^{-12}	ergs

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Energy (continued)

eV	1.6021×10^{-19}	joules (abs)
eV	10^{-3}	keV
eV	10^{-6}	MeV
ergs	10^{-7}	joules (abs)
ergs	6.2418×10^{5}	MeV
ergs	6.2418×10^{11}	eV
ergs	1.0	dyne-cm
ergs	9.480×10^{-11}	Btu
ergs	7.375×10^{-8}	ft-lb
ergs	2.390×10^{-8}	g-cal
ergs	1.020×10^{-3}	g-cm
gm-calories	3.968×10^{-3}	Btu
gm-calories	4.186×10^{7}	ergs
joules (abs)	10^{7}	ergs
joules (abs)	0.7376	ft-lb
joules (abs)	9.480×10^{-4}	Btu
g-cal/g	1.8	Btu/lb
kg-cal	3.968	Btu
kg-cal	3.087×10^{3}	ft-lb
ft-lb	1.356	joules (abs)
ft-lb	3.239×10^{-4}	kg-cal
kW-hr	2.247×10^{19}	MeV
kW-hr	3.60×10^{13}	ergs
MeV	1.6021×10^{-6}	ergs

NOTE: Energy to mass conversion under miscellaneous

DOE CORE TEST CONVERSION TABLE

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Fission

Btu	1.28×10^{-8}	grams ^{235}U fissioned[b]
Btu	1.53×10^{-8}	grams ^{235}U destroyed[b,c]
Btu	3.29×10^{13}	fissions
fission of 1 g ^{235}U	1	megawatt-days
fissions	8.9058×10^{-18}	kilowatt-hours
fissions[b]	3.204×10^{-4}	ergs
kilowatt-hours	2.7865×10^{17}	^{235}U fission neutrons
kilowatts per kilogram ^{235}U	2.43×10^{10}	average thermal neutron flu× in fuel[b,d]
megawatt-days per ton U	1.174×10^{-4}	% U atoms fissioned[e]
megawatts per ton U	$2.68 \times 10^{10}/E^{f}$	average thermal neutron flu× in fuel[b]
neutrons per kilobarn	1×10^{21}	neutrons/cm^2
watts	3.121×10^{10}	fissions/sec

[b] At 200 MeV/fission.
[c] Thermal neutron spectrum ($\alpha = 0.193$).
[d] õ(fission = 500 barns).
[e] At 200 MeV fission, in ^{235}U-^{238}U mi×ture of low ^{235}U content.
[f] E = enrichment in grams ^{235}U/gram total. No other fissionable isotope present.

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Miscellaneous

radians	57.296	degrees
eV	1.78258×10^{-33}	grams
eV	1.07356×10^{-9}	u
erg	1.11265×10^{-21}	grams
proton masses	938.256	MeV
neutron masses	939.550	MeV
electron masses	511.006	keV
u (amu on ^{12}C scale)	931.478	MeV

Temperature

$$°C = \frac{(°F - 32)}{1.8} \qquad °C = (°F - 32)\left(\frac{5}{9}\right)$$

$$°F = 1.8(°C) + 32 \qquad °F = \left(\frac{9}{5}\right)(°C) + 32$$

$$°K = °C + 273.16$$

Wavelength to Energy Conversion

keV = 12.40/Å
eV = 1.240×10^{-6}/m

AREA CONVERSION

Acre to feet

1 acre = 43,560ft^2