Radiocarbon Dating Reading Assignment
Chemistry

Name: _____

Date: _____ Hour: _____

**Radiocarbon Dating** (http://www.c14dating.com/)

The radiocarbon method was developed by a team of scientists led by the late Professor Willard F. Libby of the University of Chicago after the end of World War II. Libby later received the Nobel Prize in Chemistry in 1960 for the radiocarbon discovery.

Today, there are over 130 radiocarbon dating laboratories around the world producing radiocarbon dates for the scientific community. The $^{14}C$ method has been and continues to be applied and used in many, many different fields including hydrology, atmospheric science, oceanography, geology, palaeoclimatology, archaeology and biomedicine.

Who developed radiocarbon dating? _____

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When was this method developed? _____

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All plants and animals on Earth are made principally of carbon. During the period of a plant's life, the plant is taking in carbon dioxide through photosynthesis, which is how the plant makes energy and grows. Animals eat plants, and some eat other animals in the food chain. Carbon follows this pathway through the food chain on Earth so that all living things are using carbon, building their bodies until they die.

How do animals get carbon into their bodies? _____

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A tiny part of the carbon on the Earth is called carbon-14 ($^{14}C$), or radiocarbon. Radiocarbon is formed when $^{14}N$ in the atmosphere is changed into $^{14}C$ by cosmic rays. It is then called 'radio'-carbon, because it is 'radioactive'. This means that its atomic structure is not stable and there is an uneasy relationship between the particles in the nucleus of the atom itself. Eventually, a particle is emitted from the carbon-14 atom, and carbon-14 disappears. Most of the carbon on Earth exists in a slightly different atomic form, although it is, chemically speaking, identical to all carbon. (There is approximately one radioactive $^{14}C$ atom for every billion stable $^{12}C$ atoms.)

How is carbon-14 formed? _____

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What does it mean to be radioactive? _____

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If I had two billion stable carbon-12 atoms inside me, how many carbon-14 atoms would also be present?

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While alive, organisms have a fixed $^{12}C$ to $^{14}C$ ratio. After dying, organisms don't absorb any more $^{14}C$ from the atmosphere; the $^{14}C$ they have is radioactive and decays away. The organism's carbon ratio is then compared to the "living" ratio to estimate how long the organism has been dead.

In the 1940s, scientists succeeded in finding out how long it takes for radiocarbon to disappear, or decay, from a sample of carbon from a dead plant or animal. Willard Libby, the principal scientist, had worked in the team making the nuclear bomb during World War II, so he was an expert in nuclear and atomic chemistry. After the war he became very interested in peaceful applications of atomic science. He and two students first measured the "half-life" of radiocarbon. The half-life refers to the amount of time it takes for half the radiocarbon in a sample of bone or shell or any carbon sample to disappear. Libby found that it took 5568 years for half the radiocarbon to decay. After twice that time (about 11000 years), another half of that remaining amount will have disappeared. After another 5568 years, again another half will have disappeared. You can work out that after about 50 000 years of time, all the radiocarbon will have gone. Therefore, radiocarbon dating is not able to date anything older than 60 000 or 70 000 years old. The job of a radiocarbon laboratory is to measure the remaining amounts of radiocarbon in a carbon sample. This is very difficult and requires a lot of careful work to produce reliable dates.

What is meant by the term half-life? _____

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What is the half-life of radiocarbon? _____

How many years does it take for all the radiocarbon in a sample to decay? _____

What is measured in a radiocarbon lab? _____

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Libby tested the new radiocarbon method on carbon samples from prehistoric Egypt whose age was known. A sample of acacia wood from the tomb of the pharoah Zoser was dated for example. Zoser lived during the 3rd Dynasty in Egypt (2700-2600 BC). Libby figured that since the half-life of $^{14}C$ was 5568 years, they should obtain a radiocarbon amount of about 50% of that which was found in living wood because Zoser's death was about 5000 years ago. The results they obtained indicated this was the case. Many other radiocarbon dates were conducted on samples of wood of known age. Again, the results were good. In 1949, Libby and his team published their results. By the early 1950s there were 8 new radiocarbon laboratories, and by the end of the decade more than 20.

How was Libby sure the radiocarbon method worked? _____

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We can date rice, pollen, seeds, and tiny pieces of charcoal. We can now date a variety of very, very small samples. Many more archaeological and geological samples can be dated than before.

It is possible to test radiocarbon dates in different ways. One way is to date things that you already know the age of. Libby did this when he first developed the method, by dating artefacts of Egyptian sites, which were already dated historically. Another way is to use tree rings. Every year a tree leaves a ring, the rings increase in number over time until a pattern of rings is formed. Sometimes the tree has many hundreds of rings. Scientists can date the age of the tree by counting and measuring the rings. Radiocarbon daters can then date the tree rings and compare the dates with the real age of the tree.

How can trees be used to verify radiocarbon dates? _____

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