

The following glossary of terms is compiled to help you gain a better understanding of the play *Copenhagen*. Some of the terms you may recognize from handouts I have given you already, but there may be some references made in the dialogue that we haven't covered in class. Before watching the play, take some time to review these terms, and refer to this list as you may need to during the showing of the play. If there are any other terms, technical, historical, biographical, etc., NOT contained on this list, please don't hesitate to bring them up in class. This is by no means intended to be an exhaustive list, and there may be many more terms than presented here which may require additional outside research. Take note as you are watching the play of ANY terms or references that you are not sure about which may help you to better understand and interpret what you are watching, and what the author (Michael Frayn) is trying to convey.

A

Atom

Atoms are the smallest naturally occurring, electrically neutral form of matter and are often referred to as the "fundamental building blocks of the universe." An atom consists of a positively charged nucleus, which itself consists of protons and neutrons, surrounded by a cloud of negatively charged electrons. It should be noted that if the size of an atom is defined by the position of its outer most electrons, then the atom is almost entirely empty space.

Atomic Bomb

Atomic bomb generally refers to an explosive device that works on the principle of nuclear fission (as opposed to nuclear fusion as in the case of a hydrogen bomb). Fission bombs can use either plutonium (Pu-239) or uranium (U-235). In the latter case, several pieces of uranium, each smaller than the critical mass, are blasted together by a so-called "gun assembly", forming a super critical mass of uranium which then undergoes an explosive fission chain reaction. An example of this kind of device is the Little Boy bomb dropped on Hiroshima.

C

Cadmium

A natural element found in the earth's crust, resistant to corrosion and a good conductor of electricity. It is often used in batteries and nuclear reactors as it quickly absorbs neutrons.

Chain Reaction

A chain reaction occurs in fissionable material when neutrons from the high-energy fragments of a split nucleus induce fission in nearby nuclei; this will occur when the amount of material exceeds the so-called critical mass.

Cloud Chamber

A chamber used to see ionized particles through a supersaturated environment. The water vapor condenses around the electrical charges leaving visual tracks of liquid droplets.

Copenhagen

The capital of Denmark, located between the North Sea and the Baltic Sea. The largest city in Scandinavia, Copenhagen today has a Danish speaking population of 1.7 million people.

Critical Mass

The critical mass is the minimum mass for which a chain reaction will occur in a fissile material. The fission of a nucleus yields two fragments of approximately equal size. These fragments tend to be in a highly energetic, unstable state, and boil off excess energy by ejecting fast neutrons. An ejected neutron can then encounter another nucleus where it can induce fission, be captured by this nucleus, or just be scattered away toward another nucleus. The more nuclei this neutron encounters, the better chance it has of causing another nucleus to split.

Cyclotron

A cyclotron is a machine that accelerates charged elementary particles to very high-energy states. A beam of the particles to be accelerated moves in an evacuated chamber under the influence of a very strong magnetic field. As the charged particles rotate around the circular device, they receive an accelerating kick from an electric field twice during each orbit. After many such orbits, the charged particles are moving at speeds slightly less than the speed of light and have enormous energies.

E

Electron

Electrons are negatively charged particles that surround an atomic nucleus. Although an electron has measurable mass (about 1/1800 the mass of a proton), its special structure, if it has any, is smaller than any existing apparatus can resolve. The electrostatic attraction between the electrons and atomic nuclei is much weaker than the forces that hold the nucleus together.

F

Farm Hall

An estate in England, where, at the end of WW II, the top 10 German atomic scientists were captured and held and their conversations were secretly recorded. These tapes indicate that Heisenberg did not know how to calculate the critical mass needed to build an atomic bomb.

Fission

Fission is the process whereby a heavy, unstable nucleus splits into two approximately equal fragments, releasing an enormous amount of energy. Fission can occur spontaneously or as a result of a collision between a nucleus and an energetic particle such as a neutron.

Fusion

Fusion involves the joining of two lighter elements into a single heavier nucleus. In this case, the heavier nucleus is much more stable than the lighter nuclei, and is thus in a lower internal energy state. The difference in internal energies is released in the fusion process.

G

Geiger Counter

Developed in 1928, a device that can detect and measure radioactive activity, emissions of energy from atomic nuclei, and, in particular, those from uranium.

Gone critical

The point in an atomic chain reaction when it becomes self-sustaining.

H

Hiroshima

A coastal city in southern Japan that was devastated on August 6, 1945, by the dropping of the first atomic bomb nicknamed "Little Boy". By year's end, nearly 200,000 people had died as a result of this one bomb.

I

Isotopes

Atoms consist of electrons orbiting a tightly bound nucleus containing neutron and protons. An element's unique chemical nature derives from the number of protons in the nucleus. The number of neutrons in the nucleus effect the nuclear mass, energy and stability, but does not change its elemental identity. Isotopes are different varieties of a single element characterized by different numbers of neutrons.

L

Los Alamos

The isolated area in New Mexico where the first atomic bomb was designed and constructed by a team of scientists from the Manhattan Project. Once a private boys' school, the site was selected in 1942 because of its remote location and existing school buildings.

M

Manhattan Project

The Manhattan Engineer District, or the Manhattan Project, was the district of the Army Corps of Engineers established to coordinate and oversee the myriad projects involved in the effort to produce the first atomic bomb. The name derives from the Manhattan (New York City) location of the district headquarters.

Molecule

The smallest part something can be divided into while still being considered the same substance.

N

Nagasaki

A coastal city on the southern most tip of Japan. Three days after Hiroshima had been devastated by "Little Boy", a more powerful bomb nicknamed "Fat Boy" was dropped on Nagasaki killing approximately 70,000.

Neutron

A neutron is one of the two particles comprising atomic nuclei, with the exception of hydrogen, whose nucleus consists of a single proton. A neutron has a neutral charge and a mass slightly greater than that of the proton. While neutrons are generally stable within the nucleus, a free neutron will decay with a half-life of about twelve minutes into a proton, an electron, and an antineutrino (a massless particle of antimatter that travels at the speed of light).

Nucleus

The nucleus of an atom is the positively charged core consisting of one or more protons and, except for hydrogen, one or more neutrons. It is held together by the so-called strong nuclear forces, which is about one hundred times stronger than the electromagnetic interactions between the nuclear particles that would induce them to repel each other.

P

Plutonium

Plutonium is one of the two fissile materials used in the weapons developed at Los Alamos. A highly unstable element, plutonium did not exist on earth until it was manufactured in 1941. The isotope Pu-239 (which has 94 protons and 145 neutrons) can be produced by bombarding the Uranium isotope U-238 (92 protons and 146 neutrons) with neutrons. This isotope of plutonium has a half-life of almost 25,000 years.

Proton

A proton is one of the two types of particles found in atomic nuclei, the other type being a neutron. The proton has a positive charge equal in magnitude to that of the electron's negative charge, with a mass about equal to that of the neutron's. The number of protons in an atomic nucleus -- called the atomic number -- is what gives an element its distinctive chemical identity.

Q

Quantum Theory/ Quantum Mechanics

Quantum theory, or quantum mechanics, is the physical theory that attempts to describe the motions of atomic and sub-atomic particles. Perhaps the most interesting distinction between quantum mechanics and classical physics is that in the classical theory, if a particle's position and momentum are known at some point, together with all forces acting on it, then its motion at any time in the future can be known exactly. In this sense, classical physics is deterministic. In quantum mechanics, on the other hand, exact predictions of a particle's motion cannot be made; only statistical probabilities can be calculated. Also, because measurements on a quantum system actually change its state, the concept of information is much more complicated than it is in classical physics; indeed, it is not even possible to measure position and momentum simultaneously for a quantum system.

R

Radiation Sickness

Radiation injury such as vomiting or nausea caused by exposure to high doses of radiation. With exposure levels above 1,000 rad, death often occurs within 4 weeks.

Relativity, Theory of

Developed by Albert Einstein, this theory states that matter and energy were really the same thing only in different form. If matter could be converted into energy, large amounts of power would be released.

S

Schrodinger Wave Equation

Developed by Erwin Schrodinger in 1926, it was a way of explaining the movement of an electron around an atom in the form of a wave. It was, in many ways, a visual representation of Werner Heisenberg's matrix mechanics.

U

U-235

While making up only 0.7% of natural Uranium, this is the fissionable part of the element that has neutrons that move slowly enough to sustain a chain reaction.

U-238

Uranium is a rock like element found in the earth which is made up of 99.3% U-238 and .7% U-235. U 238 is not fissionable and therefore relatively safe. It has the largest atomic nucleus of any element.

Uncertainty Principle

A principle of quantum mechanics developed by Werner Heisenberg in the 1920s which asserts that it is not possible to determine the position and momentum of a particle at the same instant. The act of observing the particle will in some way affect its behavior.