AQA Physics GCSE Student Progress

Unit 4.4 - Atomic Structure

4.4.1. Atoms and Isotopes

4.4.1.1. The Structure of the Atom

a	I know that atoms are very small, having a radius of about 1×10^{-10} metres.			
b	I know that the basic structure of an atom is a positively charged nucleus composed of both protons and neutrons surrounded by negatively charged electrons.			
c	I know that the radius of a nucleus is less than 1/10 000 of the radius of an atom and that most of the mass of an atom is concentrated in the nucleus.			
d	I know that the electrons are arranged at different distances from the nucleus (different energy levels).			
e	I know that the electron arrangements may change with the absorption of electromagnetic radiation (move further from the nucleus; a higher energy level) or by the emission of electromagnetic radiation (move closer to the nucleus; a lower energy level).			

4.4.1.2. Mass Number, Atomic Number and Isotopes

a	I know that, in an atom, the number of electrons (-1, negative charge) is equal to the number of protons (+1, positive charge) in the nucleus and therefore, atoms have no overall electrical charge.			
b	I know that all atoms of a particular element have the same number of protons and that the number of protons in an atom of an element is called its atomic number.			
c	I know that the total number of protons and neutrons in an atom is called its mass number.			
d	I know that atoms can be represented as shown in this example: (Mass number) (Atomic number) $^{23}_{11}Na$			
e	I know that atoms of the same element can have different numbers of neutrons and that these atoms are called isotopes of that element.			
f	I know that atoms turn into positive ions if they lose one or more outer electron(s).			

4.4.1.3. The Development of the Model of the Atom (common content with Chemistry)

a	I know that new experimental evidence may lead to a scientific model being changed or replaced.			
b	I know that, before the discovery of the electron, atoms were thought to be tiny spheres that could not be divided.			
c	I can describe how the discovery of the electron led to the plum pudding model of the atom and that this model suggested that the atom is a ball of positive charge with negative electrons embedded in it.			
d	I can describe how the results from the alpha particle scattering experiment led to the conclusion that the mass of an atom was concentrated at the centre (nucleus) and that the nucleus was charged. This nuclear model replaced the plum pudding model.			
e	I know that Niels Bohr adapted the nuclear model by suggesting that electrons orbit the nucleus at specific distances and that the theoretical calculations of Bohr agreed with experimental observations.			
f	I know that later experiments led to the idea that the positive charge of any nucleus could be subdivided into a whole number of smaller particles, each particle having the same amount of positive charge. The name proton was given to these particles.			
g	I know that the experimental work of James Chadwick provided the evidence to show the existence of neutrons within the nucleus. This was about 20 years after the nucleus became an accepted scientific idea.			
h	I can describe the difference between the plum pudding model of the atom and the nuclear model of the atom.			

4.4.2. Atoms and Nuclear Radiation

4.4.2.1. Radioactive Decay and Nuclear Radiation

a	Some atomic nuclei are unstable. The nucleus gives out radiation as it changes to become more stable. This is a random process called radioactive decay.			
b	I know that the nuclear radiation emitted may be: • an alpha particle (α) – this consists of two neutrons and two protons, it is the same as a helium nucleus; • a beta particle (β) – a high speed electron ejected from the nucleus as a neutron turns into a proton; • a gamma ray (γ) – electromagnetic radiation from the nucleus; • a neutron (n).			
c	I know that activity is the rate at which a source of unstable nuclei decays and that it is measured in becquerel (Bq).			
d	I know that count-rate is the number of decays recorded each second by a detector (eg Geiger-Muller tube).			
e	I can describe the properties of alpha particles, beta particles and gamma rays (limited to their penetration through materials, their range in air and ionising power).			
f	I can describe the uses of radiation and evaluate the best sources of radiation to use in a given situation.			

4.4.2.2. Nuclear Equations

a	I know that nuclear equations are used to represent radioactive decay.			
b	I know that in a nuclear equation an alpha particle may be represented by the symbol: $^{4}_{2}\text{He}$ and a beta particle by the symbol: $^{0}_{-1}\text{e}$			
c	I know that the emission of the different types of nuclear radiation may cause a change in the mass and /or the charge of the nucleus. For example: $^{219}_{86}\text{radon} \longrightarrow {}^{215}_{84}\text{polonium} + {}^{4}_{2}\text{He}$ so alpha decay causes both the mass and charge of the nucleus to decrease. $^{14}_{6}\text{carbon} \longrightarrow {}^{14}_{7}\text{nitrogen} + {}^{0}_{-1}\text{e}$ so beta decay does not cause the mass of the nucleus to change but does cause the charge of the nucleus to increase.			
d	I know that the emission of a gamma ray does not cause the mass or the charge of the nucleus to change.			
e	I can use the names and symbols of common nuclei and particles to write balanced equations that show single alpha (α) and beta (β) decay (limited to balancing the atomic numbers and mass numbers).			

4.4.2.3. Half Lives and the Random Nature of Radioactive Decay

a	I know that radioactive decay is random.			
b	I know that the half-life of a radioactive isotope is the time it takes for the number of nuclei of the isotope in a sample to halve, or the time it takes for the count rate (or activity) from a sample containing the isotope to fall to half its initial level.			
c	I can determine the half-life of a radioactive isotope from given information.			
d	I can calculate the net decline, expressed as a ratio, in a radioactive emission after a given number of half-lives (HT Only).			

4.4.2.4. Radioactive Contamination

a	I know that radioactive contamination is the unwanted presence of materials containing radioactive atoms on other materials and that the hazard from contamination is due to the decay of the contaminating atoms.			
b	I know that the type of radiation emitted affects the level of hazard.			
c	I know that irradiation is the process of exposing an object to nuclear radiation and that the irradiated object does not become radioactive.			
d	I can compare the hazards associated with contamination and irradiation.			
e	I know that precautions must be taken to protect against any hazard that the radioactive source used in the process of irradiation may present.			
f	I know that it is important for the findings of studies into the effects of radiation on humans to be published and shared with other scientists so that the findings can be checked by peer review.			

4.4.3. Hazards and Uses of Radioactive Emissions and of Background Radiation (Physics Only)

4.4.3.1. Background Radiation (Physics Only)

a	I know that background radiation is around us all of the time and that it comes from: • natural sources such as rocks and cosmic rays from space; • man-made sources such as the fallout from nuclear weapons testing and nuclear accidents.			
b	I know that the level of background radiation and radiation dose may be affected by occupation and / or location.			
c	I know that radiation dose is measured in sieverts (Sv). 1000 millisieverts (mSv) = 1 sievert (Sv).			

4.4.3.2. Different Half Lives of Radioactive Isotopes (Physics Only)

a	I know that radioactive isotopes have a very wide range of half-life values.			
b	I can explain why the hazards associated with radioactive material differ according to the half-life involved.			

4.4.3.3. Uses of Nuclear Radiation (Physics Only)

a	I know that nuclear radiations are used in medicine for the: • exploration of internal organs; • control or destruction of unwanted tissue.			
b	I can describe and evaluate the uses of nuclear radiations for exploration of internal organs, and for control or destruction of unwanted tissue.			
c	I can evaluate the perceived risks of using nuclear radiations in relation to given data and consequences.			

4.4.4. Nuclear Fission and Fusion (Physics Only)

4.4.4.1. Nuclear Fission (Physics Only)

a	I know that nuclear fission is the splitting of a large and unstable nucleus (e.g. uranium or plutonium).			
b	I know that spontaneous fission is rare and that usually, for fission to occur, the unstable nucleus must first absorb a neutron.			
c	I know that the nucleus undergoing fission splits into two smaller nuclei, roughly equal in size, and emits two or three neutrons plus gamma rays and that energy is released by the fission reaction.			
d	I know that all of the fission products have kinetic energy and that the neutrons may go on to start a chain reaction.			
e	I know that the chain reaction is controlled in a nuclear reactor to control the energy released.			
f	I know that the explosion caused by a nuclear weapon is caused by an uncontrolled chain reaction.			
g	I can draw and interpret diagrams representing nuclear fission and how a chain reaction may occur.			

4.4.4.2. Nuclear Fusion (Physics Only)

a	I know that nuclear fusion is the joining of two light nuclei to form a heavier nucleus and that in this process some of the mass may be converted into the energy of radiation.			