Physics You Learned

Physics Concepts	Is There an Equation?
There are two varieties of electric charges–positive and negative. Like electric charges repel, and unlike electric charges attract.	
For a macroscopic object, a positive charge is caused by a deficiency of **electrons** and a negative charge is caused by an excess of electrons.	
Grounding a charged object allows the excess charge to be sent to Earth, reducing the net charge on the object to zero.	
Charge is measured in coulombs. One coulomb (C) has a charge equal to 6.25×10^{18} electrons.	
The law of **conservation of charge** states that charge cannot be created or destroyed, but may be transferred, causing local imbalances.	
The force between two charges is proportional to the product of their magnitudes, and inversely proportional to the distance between them, squared.	$F_c = \frac{kq_1q_2}{d^2}$
Robert Millikan proved that the electron is the fundamental unit of charge and that the charge is quantized. The charge on the electron is equal and opposite to the charge on the **proton** with a value of 1.6×10^{-19} C.	
Indirect measurement and inference are often the only means to develop knowledge about the **atom**, since it is too small to be observed directly.	
The Rutherford experiment proved the existence of the atomic **nucleus** by bombarding atoms with positively charged **alpha particles**.	
Atoms may be identified by the radiation (spectrums) that they emit. The spectral signature of each atom is unique.	
The Bohr model of the atom assumes electrons revolve around the nucleus and may only exist in certain specified orbits.	
The energy of the **photon** of light emitted by an atom (E_p) equals the electron's initial energy state (E_i) minus the electron's final energy state (E_f). According to the Bohr model, light may only be emitted or absorbed by the atom in specified quanta equal to the difference in the atom's energy levels.	$E_p = E_i - E_f$
Active Physics *Plus* The energy of a photon (E_p) equals the photon's **frequency** (f) multiplied by Planck's constant (h). The speed c of the emitted photon equals the frequency times the wavelength.	$E_p = hf$ $c = f\lambda$
Photons of light and matter on the atomic scale have both wave and particle characteristics, although they only exhibit one behavior at a time. This is known as the wave-particle duality of light and matter.	
Interference of light demonstrates a photon's wave characteristics.	
The **photoelectric effect** demonstrates a photon's particle characteristics.	

In the photoelectric effect, the kinetic energy ($KE_{electron}$) of an electron ejected from an atom by a photon equals the energy of the photon (E_p) minus the work function (w_o) of the atom where the energy of the photon is hf.	$KE_{electron} = E_p - w_o$ $KE_{electron} = hf - w_o$
The location of the electron in the atom is determined by the probabilities described in the Schroedinger wave equation.	
Active Physics Plus — The wavelength of light or a particle passing through a **diffraction** grating may be calculated using Young's double-slit formula. The wavelength (λ) equals the distance between grating lines (d) times the distance from the central maximum to the first maximum, divided by the distance from the grating to the screen.	$\lambda = \frac{dx}{L}$
The nucleus has all the positive charge and almost all the mass of the atom. The nucleus is composed of protons and **neutrons** (collectively called **nucleons**).	
The **atomic number** (Z) of a nucleus is the proton number. The atomic mass number (A) is the sum of the protons and neutrons. The neutron number (N) in a nucleus is the atomic mass number minus the atomic number.	$N = A - Z$
The nucleus is held together by a **strong force** caused by the exchange of **virtual particles** called **mesons**.	
There are three main types of radioactive decay: alpha, beta, and gamma radiation, all of which carry energy away from the nucleus. Both charge and energy are conserved during radioactive decay.	
During **alpha decay**, the atomic number of the parent nucleus decreases by 2 while the atomic mass number decreases by 4.	
During **beta decay**, the parent nucleus atomic mass number remains the same, but the atomic number increases by 1 for negative beta decay.	
Gamma radiation does not change the atomic number or the atomic mass number.	
The half-life of a radioactive material is the time required for half of the non-disintegrated atoms to decay.	
Active Physics Plus — Radioactive decay is governed by the rules of **probability**. The number of **particles** (N) remaining after a period of radioactive decay equals the original number (N_o) divided by the number 2 raised to the number of half-lives.	$N = \frac{N_o}{2^n}$
The nuclear **binding energy** holding the nucleus together comes from the mass converted into energy as the nucleus was assembled. Energy (E) equals mass (m) times the speed of light (c), squared.	$E = mc^2$
The mass converted into energy as the nucleus is assembled is called the **mass defect**, and is found by subtracting the mass of the nucleus from the mass of its individual components when they are not part of a nucleus.	
The greater the binding energy per nucleon, the more stable the nucleus is.	
Fission occurs when heavy nuclei, such as uranium, are split apart into light nuclei, liberating energy.	
Fusion occurs when lighter nuclei, such as hydrogen, are combined together, liberating energy.	