Electrical Current

Elementary Charge and the Coulomb

In the modern atom, a small, dense nucleus contains protons and neutrons. This nucleus is surrounded by a much larger electron cloud, which shows the areas where fast-moving electrons are most likely to be found.

Protons have a positive electrical charge, and electrons have a negative charge. Neutrons are electrically neutral (have no charge). We describe the properties of particles using ***relative charge***: a proton is +1, an electron is –1, and a neutron is 0.

An atom is electrically neutral when the number of protons (+1) and electrons (-1) is equal. However, atoms can gain or lose electrons to become charged particles called ions.

The charge on a proton and electron is too small for practical macroscopic electrical measurements such as current flowing through a circuit. Thus, a measurement of electrical charge called the Coulomb (C) is used, where the magnitude of charge on a proton or electron is defined as the ***elementary charge***, *e*, equal to $1.602176634\times10^{-19}$ C. With this definition, it takes over 6.24 quintillion (6.24×10^{18}) electrons to make one Coulomb!

Standard Prefixes		
T	Tera	10^{12}
G	Giga	10^{9}
M	Mega	10^{6}
k	kilo	10^{3}
m	milli	10^{-3}
u	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}

1. Provide the values in the space provided. Round to three significant digits and, where applicable, explicitly write all formulas and show all steps of any calculations.

a) The approximate number of electrons in one Coulomb.

b) The value of *e*, the *elementary charge*, in Coulombs (C).

c) The charge of a neutron, in Coulombs (C).

d) The charge of an electron, in Coulombs (C).

e) The charge on a proton, in Coulombs (C).

f) The population of people on earth is currently approaching 9 billion (9×10^{9}). What is the charge on 9 billion electrons, in Coulombs (C). Write the final answer using a standard prefix.

g) Avogadro's number (N_a), the number of particles in one mole of a substance is defined as 6.022×10^{23} mol^{-1}. The ***Faraday constant*** (F), a fundamental constant in electrochemistry, is defined as the charge on one mole of electrons. Calculate the *Faraday constant*.

h) When iron rusts, the iron atom is in a +3 oxidation state. Calculate the charge on each Fe^{3+} iron atom.

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An ***electrical current*** is a net flow of electrical charge. This occurs when a conductor is placed in an electric field. The magnitude of current (I) is the amount of electrical charge (Q) moving past a point per unit time (t), shown by the formula to the right. Current is measured using the unit: ***ampere***, or ***amp*** (A). One ampere is equal to one Coulomb of charge per second.

$$I = \frac{Q}{t}$$

2. Provide the answers in the space provided. For calculations, explicitly write the formula, show all steps, and round to three significant digits. Write the final answer using standard prefixes.

a) What is the name of the unit of measurement for electrical charge?

b) What is the name of the unit of measurement for electrical current?

c) If 12.5×10^{18} electrons move through a lamp in 3.2 seconds, what current is flowing through the lamp?

d) How many Coulombs of charge move through an ammeter in one minute if the reading is 0.950A?

e) How long would it take for a current of 0.680A to move 100 billion electrons past a certain point?

e) In an electrolysis experiment, 0.01 moles of Cu^{2+} ions move through the copper sulfate solution in 23 minutes. How much average current flows?