PHYSICS 1B – Fall 2007

Electricity

&

Magnetism

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SERF Building. Room 333

UCSD

UCSD

What score do I think I received on the quiz:

- A. 0 out of 10
- B. 1-3 out of 10
- C. 4-6 out of 10
- D. 7-9 out of 10
- E. 10 out of 10

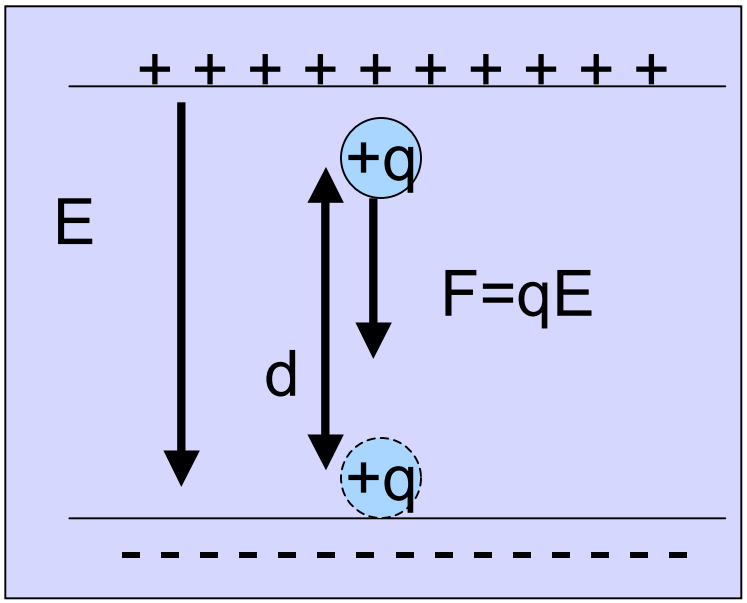
Quiz Grades: Up on 1B website this week

Chapter 16 Electrical Potential

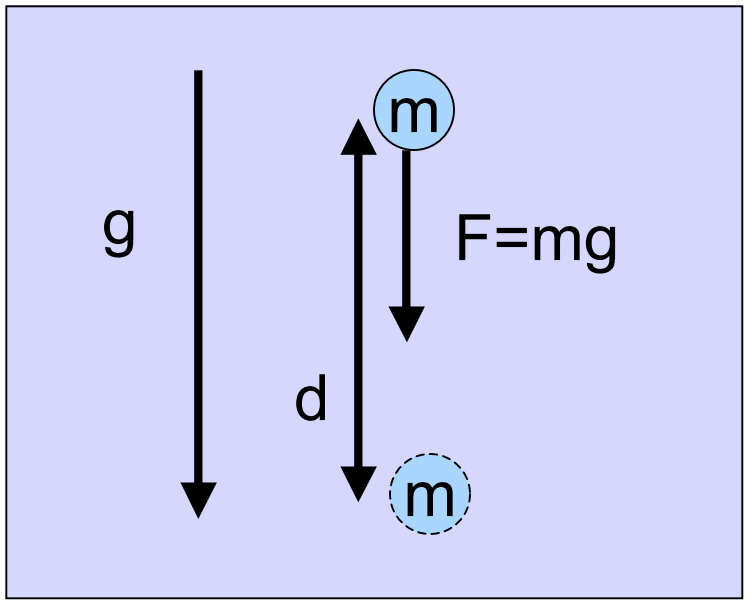
Electrical potential energy

Electrical potential

Potential Energy of a system of charges and masses (the field is uniform, constant)



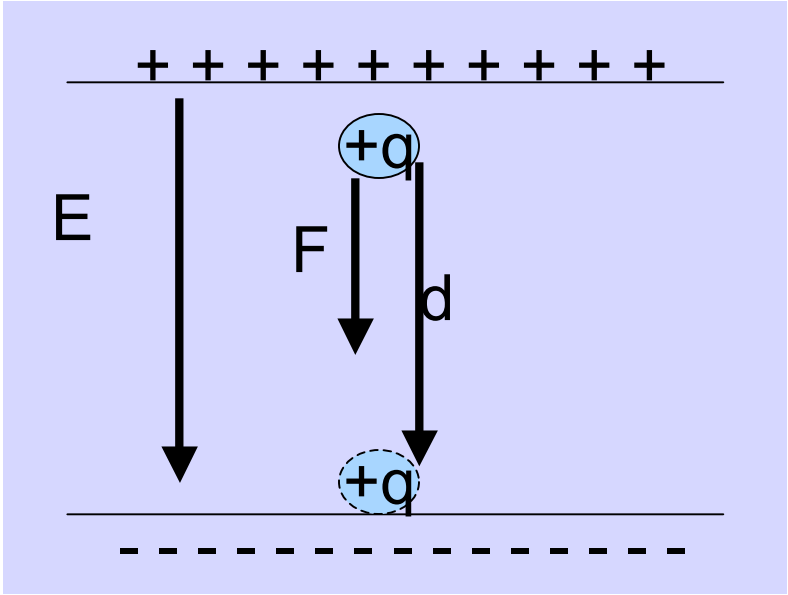
work done by Electric field



work done by Gravitational field

Change in PE =-work done by the field

Potential Energy of a system of charges



$\Delta PE=-qEd$

Work done by the Electric field decreases the PE of the system

$W= Fd$

$\Delta PE=-W=-Fd=-qEd$

Potential, V

$$V = \frac{\Delta PE}{q}$$

$$\text{Units} \quad \frac{Joules}{Coulomb} = \text{Volt (V)}$$

Relation between E and V

$$V = Ed$$

$$E = \frac{V}{d}$$

E has units of V/m

Difference between Potential Energy and Potential

Potential-Depends only position in the field. Units (V)

Potential Energy- Depends on the interaction of the field with a charge. Units (J)

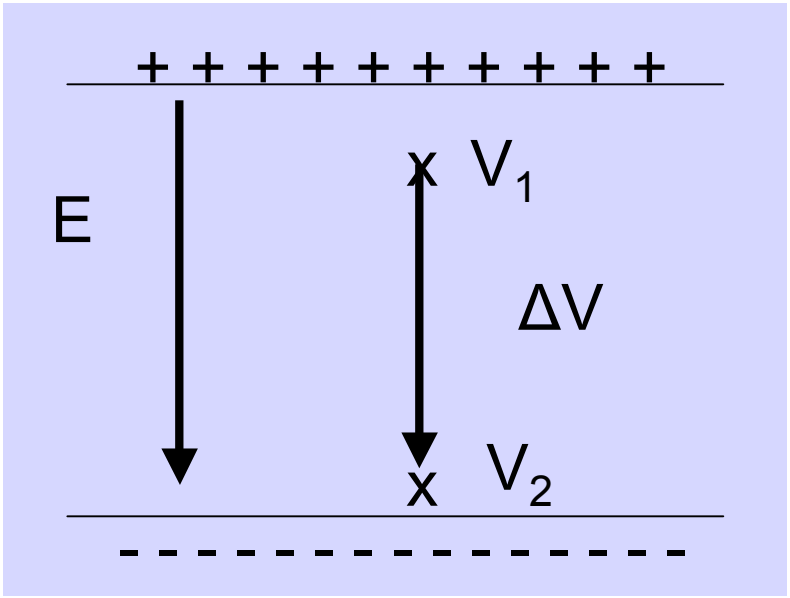
Related by

$$\Delta PE = q\Delta V$$

Both PE and V are relative.

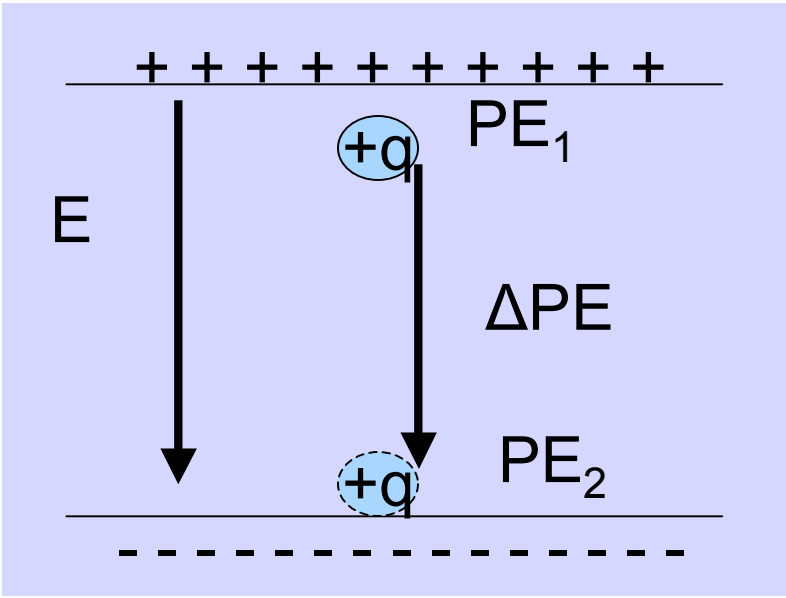
Only differences/changes in Potential Energy and Voltage (ΔPE and ΔV) are important.

Potential



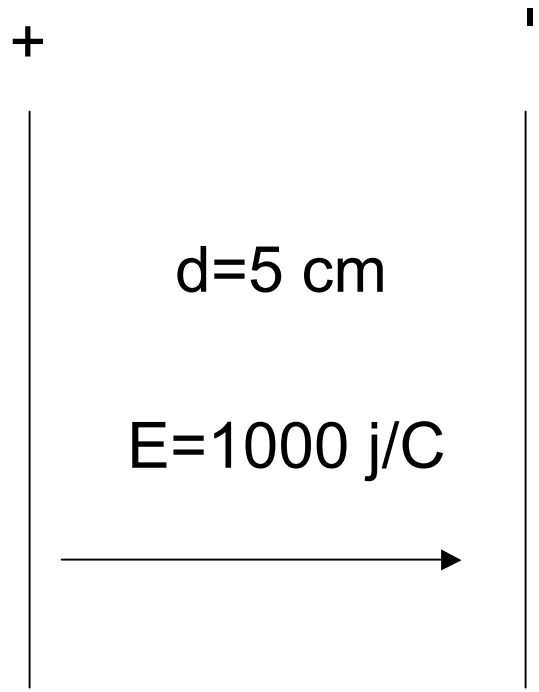
The potential field is a property of the space due to charges

Potential Energy



The potential energy is due to the charge interacting with the potential field.

A parallel plate capacitor has a constant electric field of 1000V/m. The distance between the plates is 5 cm. Find the potential difference between the two plates.



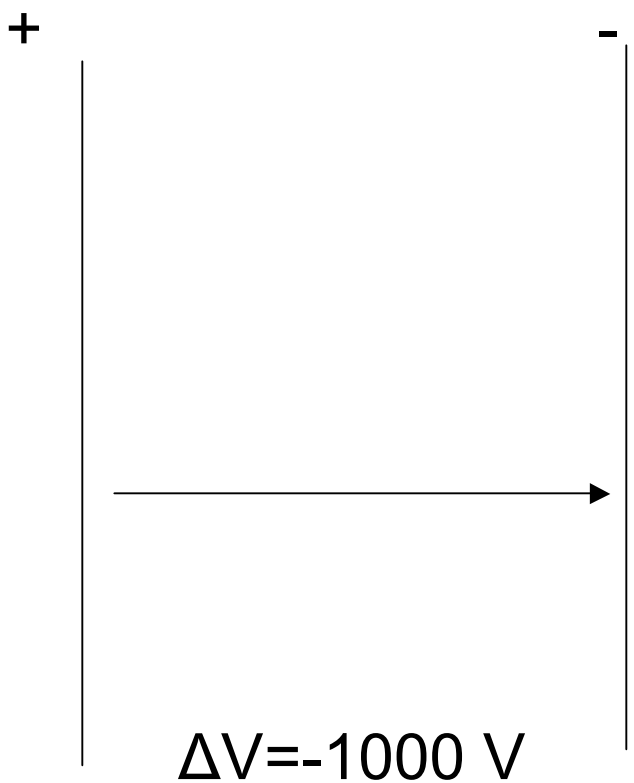
$$\Delta V = \frac{\Delta PE}{q} = \frac{qEd}{q} = Ed$$

$$\Delta V = 1000(0.05) = 50V$$

Potential Energy = Voltage?

- (T) True
- (F) False

An molecular ion CO^+ is accelerated from rest across a potential difference of 1000 V. Find the final velocity of the ion. Mass=$4.7x10^{-26}$ kg



$\Delta PE = q\Delta V$

Conservation of Energy

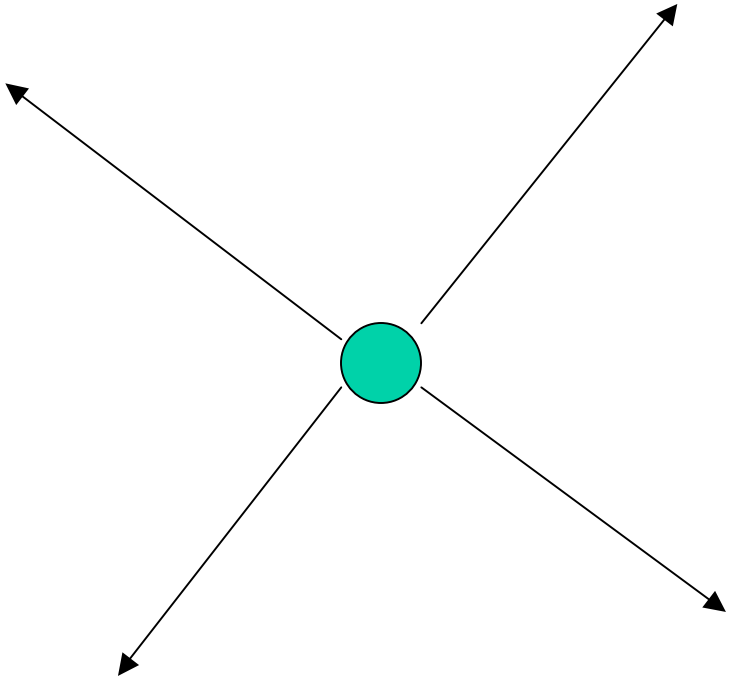
$\Delta PE + \Delta KE = 0$

$$\Delta KE = -\Delta PE = -q\Delta V = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2q(-\Delta V)}{m}} = \sqrt{\frac{2(1.6x10^{-19})(1000)}{4.7x10^{-26}}}$$

$$v = 8.25x10^4 m/s$$

Potential due to a point charge



E field is not constant

$$E = \frac{k_e q}{r^2}$$

E gets smaller with distance

The potential

$$V = \frac{k_e q}{r}$$

V=0 at $r = \infty$

Dimensional arguments

V=Electric field x length e.g. for constant field

V=Ed

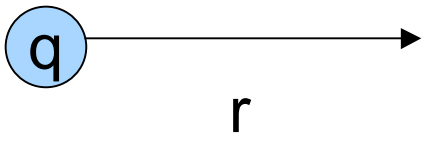
For point charge

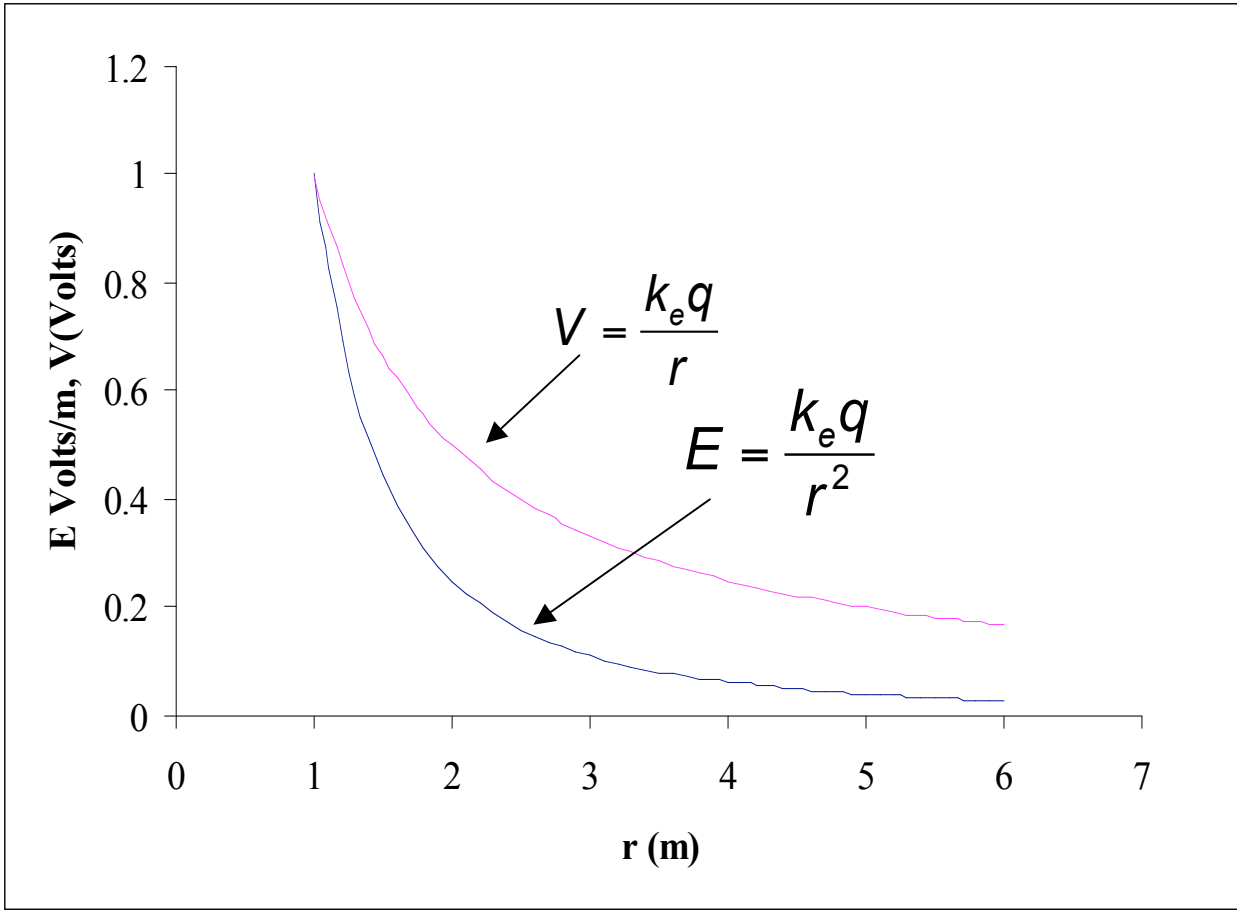
$$E = \frac{k_e q}{r^2}$$

$$V = \frac{k_e q}{r}$$

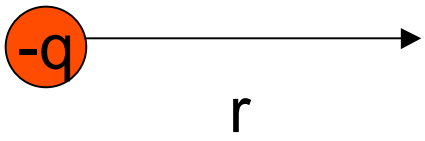
V has the appropriate units of E times length

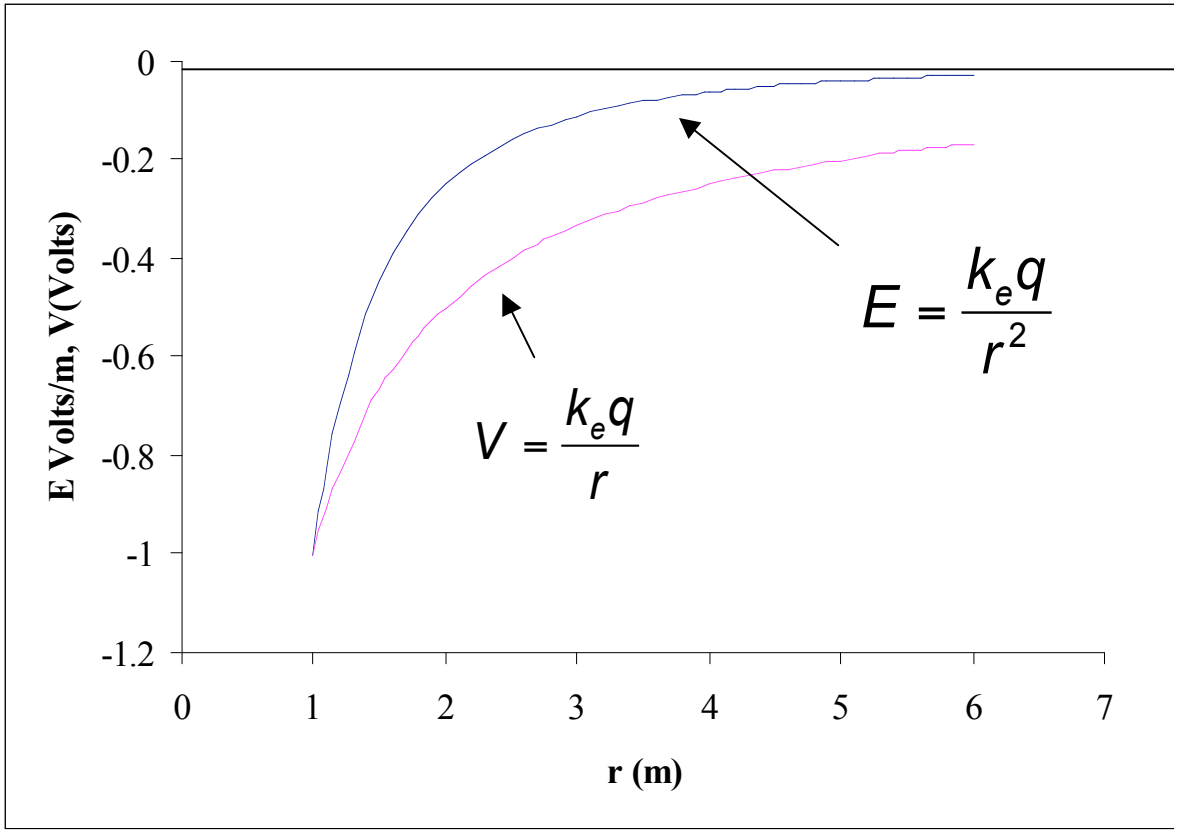
Potential and E field due to positive point charge





E and V due to a negative point charge





Potential energy of 2 point charges

$$PE = q_1 V_{21} = q_2 V_{12}$$

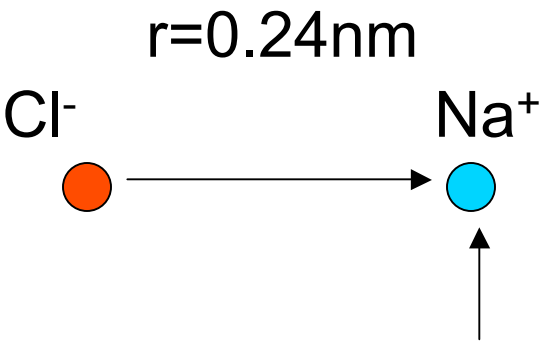
V_{21} is the potential due to charge2 at the position of charge1.

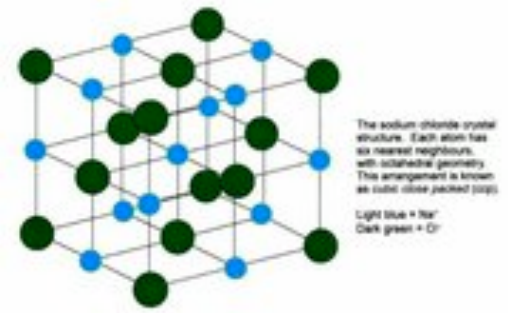
$$PE = \frac{k_e q_1 q_2}{r_{12}}$$

$PE = 0$ at r= ∞

Potential energy and Potential are Scalar (not Vector) quantities

In a crystal of Na^+ Cl^- the distance between the ions is 0.24 nm. Find the potential due to Cl^- at the position of the Na^+. Find the electrostatic energy of the Na^+ due to the interaction with Cl^-.





$$V = \frac{k_e q}{r} = \frac{9x10^9(-1.6x10^{-19})}{(0.24x10^{-9})} = -6.0V$$ at the position of Na+

PE=qV =1.6x10^{-19}x-6.0 = -9.6x10^{-19}J

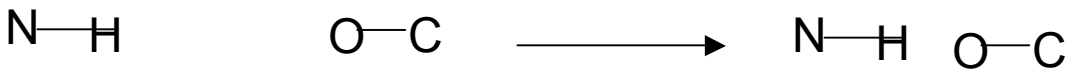
ELECTRON VOLT (convenient unit for atomic physics)

1eV=1.6x10^{-19} J

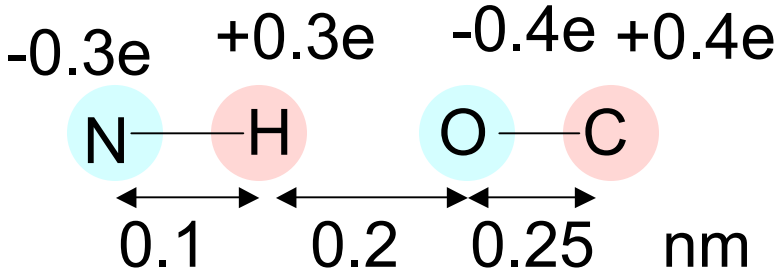
PE=-6.0 eV

(energy in eV is V times the charge in electron units)

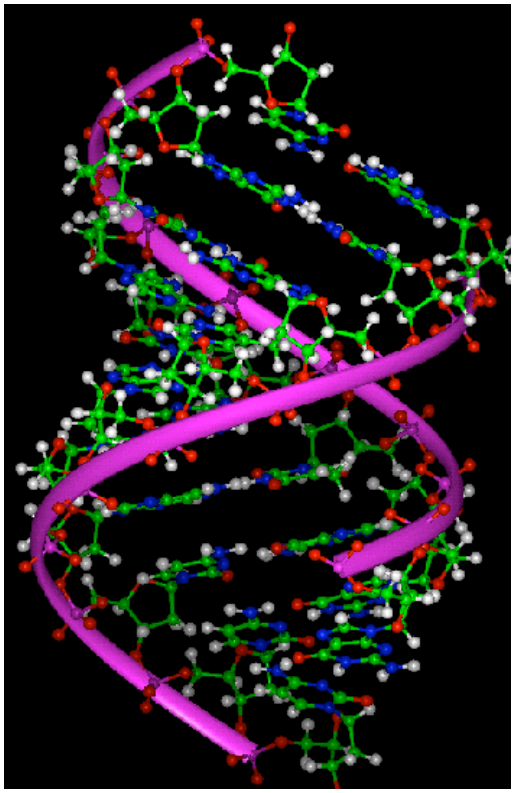
Hydrogen Bond



The hydrogen bond energy can be estimated by partial charges



bond energy =sum $\frac{kq_iq_j}{r_{ij}}$ (scalar sum)



DNA

$$\Delta PE = \frac{ke^2}{10^{-9}}\left(\frac{(-.3)(-.4)}{.1+.2}+\frac{-.3(.4)}{.1+.2+.25}+\frac{+.3(-.4)}{.2}+\frac{.3(.4)}{.2+.25}\right) = -3.49\text{x}10^{-20}\,\text{J}$$

ΔPE=-0.22 eV

Weaker than a ionic bond but still significant.