Electrostatics – Part 3

Quantization of Charge

One electron is a very small amount of charge; objects generally gain or lose millions of electrons at a time, not just one. So the collective name for a large amount of electrons' charge is **Coulombs**.

*Think of the collective name for eggs. We say one dozen eggs = 12 eggs.

One **Coulomb** contains 6,24 $\times 10^{18}$ electrons

So instead of saying that an object has lost or gained 12,48 x 10^{18} electrons, we would just say 2 coulombs of charge (the unit for Coulombs is C).

Instead of 3,12 x 10^{18} electrons, it equals to $\frac{3,12 \times 10^{18}}{6,24 \times 10^{18}}$ = 0,5 C (coulombs)

Calculate how many Coulombs of charge are in each of the following:

2.1 1,56 x 10^{18} electrons = $\frac{\quad \times 10^{18}}{6,24 \times 10^{18}}$ = C (coulombs)

2.2 3,744 x 10^{19} electrons = $\frac{\quad \times 10^{19}}{6,24 \times 10^{18}}$ = C (coulombs)

2.3 24, 21 x 10^{18} electrons = $\frac{\quad \times 10^{18}}{6,24 \times 10^{18}}$ = C (coulombs)

Answers rounded off to 2 decimal places

Charge is quantized

IF One **Coulomb** = 6,24 $\times 10^{18}$ electrons

THEN The charge on one electron = 1,6 x 10^{-19}C.

Thus two electrons would have a charge of 3,2 x 10^{-19}C

20 electrons would have a charge of 3.2 x 10^{-18}C

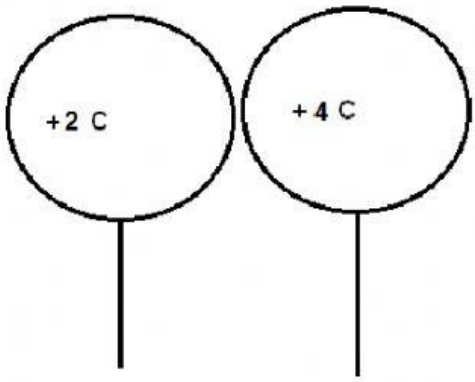
Therefore charged objects always have a charge that is a multiple of 1,6 x 10^{-19}C because they can only gain or lose a whole number of electrons.

This is what we mean when we say **Charge is quantized**.

We will now do some calculations to determine the new charge on objects after they have touched, but this time instead of just using number of electrons, we will use the charge in Coulombs. The formula for calculating Q_{new} is the same as we used before. Remember that BOTH objects will have the charge Qnew after they have touched as the electrons distribute themselves equally over the 2 objects.

Calculate the charge on each sphere after they have touched

1.



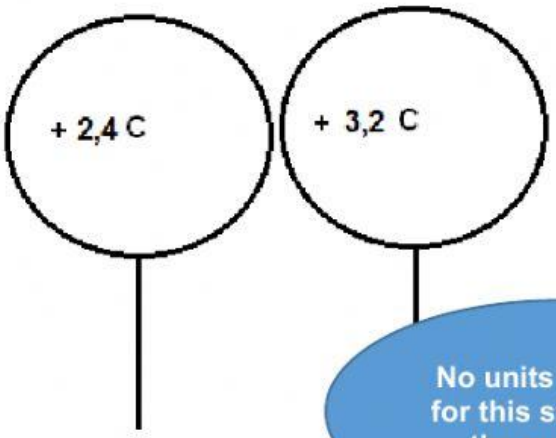
After these two objects have touched they will each have the following charge:

$$Q_{new} = \frac{Q1 + Q2}{2}$$

$$= \frac{2 + 4}{2}$$

$$= \quad C$$

2.



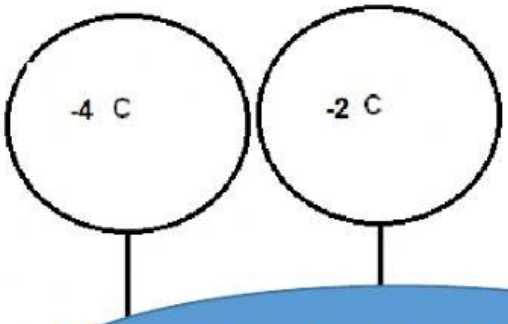
$$Q_{new} = \frac{Q_1 + Q_2}{2}$$

$$= \frac{\quad + \quad}{2}$$

$$= \quad C$$

No units required for this step – just the numbers

3.



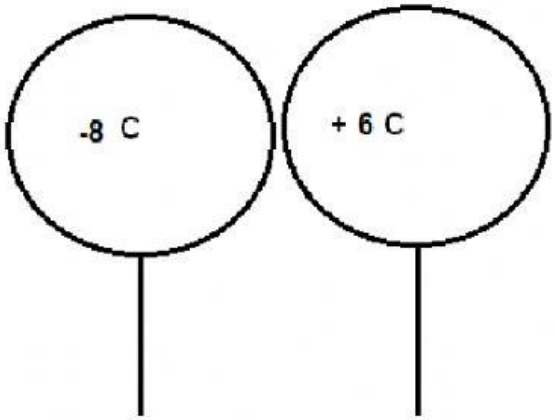
$$Q_{new} = \frac{Q_1 + Q_2}{2}$$

$$= \frac{\quad + \quad}{2}$$

$$= \quad C$$

Don't forget to include the - sign if it is a negative charge; if it's positive, don't enter the + sign

4.

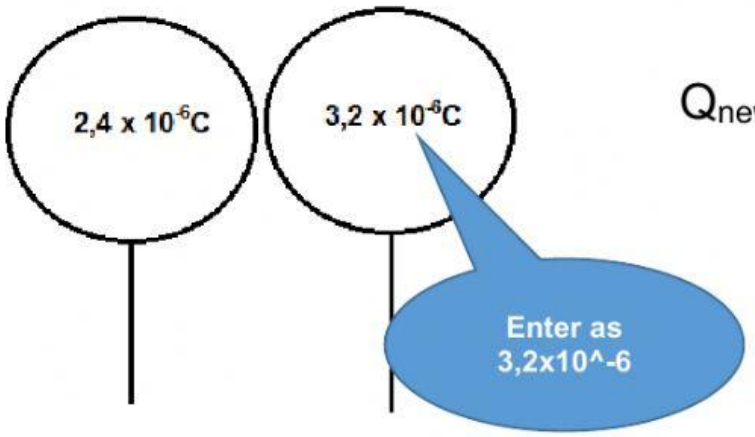


$$Q_{new} = \frac{Q_1 + Q_2}{2}$$

$$= \frac{\quad + \quad}{2}$$

$$= \quad C$$

5.

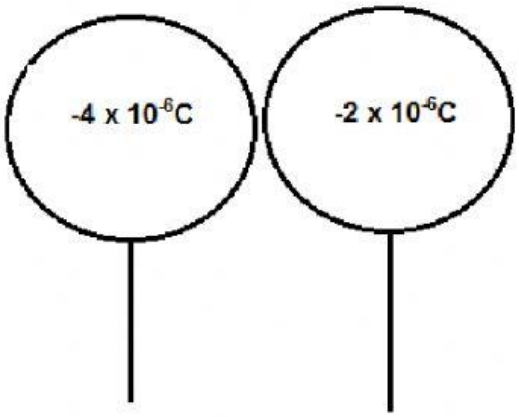


$$Q_{new} = \frac{Q_1 + Q_2}{2}$$

$$= \frac{\quad + \quad}{2}$$

$$= \quad C$$

6.

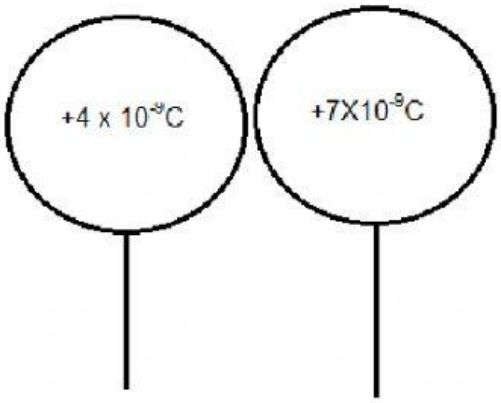


$$Q_{new} = \frac{Q_1 + Q_2}{2}$$

$$= \frac{\quad + \quad}{2}$$

$$= \quad C$$

7.

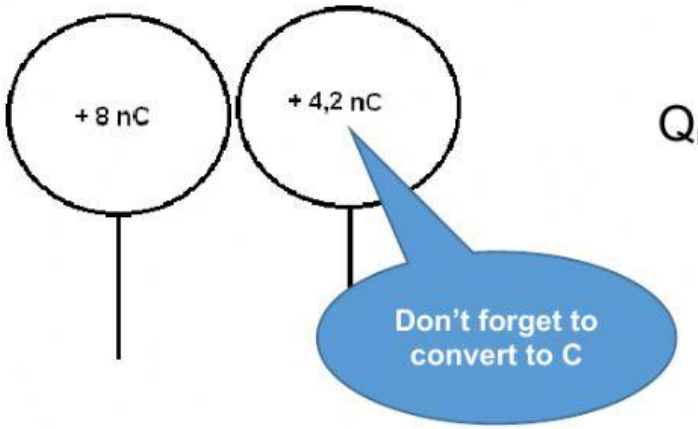


$$Q_{new} = \frac{Q_1 + Q_2}{2}$$

$$= \frac{\quad + \quad}{2}$$

$$= \quad C$$

8.

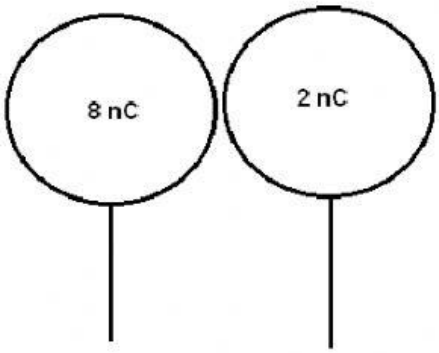


$$Q_{new} = \frac{Q_1 + Q_2}{2}$$

$$= \frac{\quad + \quad}{2}$$

$$= \quad C$$

9.

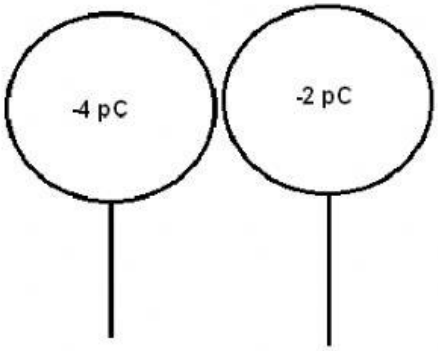


$$Q_{new} = \frac{Q_1 + Q_2}{2}$$

$$= \frac{\quad + \quad}{2}$$

$$= \quad C$$

10.

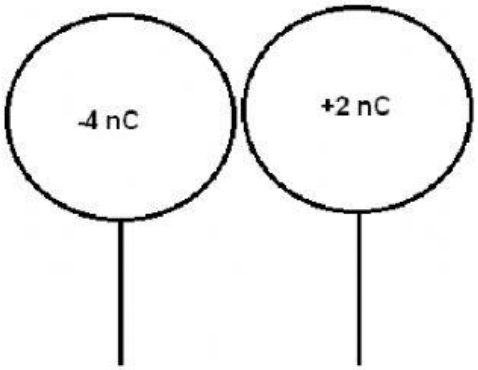


$$Q_{new} = \frac{Q_1 + Q_2}{2}$$

$$= \frac{\quad + \quad}{2}$$

$$= \quad C$$

11.



$$Q_{new} = \frac{Q_1 + Q_2}{2}$$

$$= \frac{\quad + \quad}{2}$$

$$= \quad C$$