Name: **Period:**   **Seat#:**

If you learn how to apply Coulomb's Law you will be able to:
- Predict and explain Periodic Trends such as atomic radius, ionic radius, and ionization energy.
- Predict trends in lattice energy.
- Use trends in lattice energy to predict solubility of ionic compounds in water.

Simple stuff, right? If you can answer these, using only a Periodic Table, as quickly as you can read the – then you already know and use Coulomb's Law. If not here's how it works:

$$\text{Coulomb's Law:}\quad F = k\frac{Q_1 Q_2}{r^2}$$

Hopefully you recognize this as the equation for electrostatic attraction/repulsion, often referred to as the "inverse square" law. It applies to charged particles, magnets, gravitation, etc. But we are not interested in **F**orces, we are interested in **E**nergies (such as ionization energy, lattice energy, etc). So we perform a little calculus and we get:

$E = k\, k\frac{Q_1 Q_2}{r^2}$ (and since we are not calculating, just comparing, let's simplify to $E \propto k\frac{Q_1 Q_2}{r^2}$)

> E = energy of attraction or repulsion between charged particles
> Q_1 = charge of first particle
> Q_2 = charge of second particle
> r = distance between charged particles

In chemistry, we apply Coulomb's Law in 2 situations:
- A. Individual Particles such as atoms or ions. (Ionization Energy)
- B. Ionic Compounds. (Lattice Energy)

The variables take different values in these situations, so let's look at them separately.

A. Applying Coulomb's Law to Atoms and Ions

E = *ionization energy*, the energy needed to remove the outermost electron. The greater the ionization energy, the stronger the attraction and the more energy needed to remove that electron.

Q_1 = charge of an electron, -1.

Q_2 = *effective nuclear charge* of protons in nucleus. Attraction for a valence electron is partially shielded by the inner shell electrons. The simple way to estimate effective nuclear charge is to start with the atomic number (total protons) and subtract the number of inner shell electrons. So Hydrogen has an effective nuclear charge of 1 (1 – 0 = 1.) Helium is 2. Lithium is 1 (3 – 2 = 1.) Sodium is 1 (11 – 10 = 1.) All transition metals are 2. All halogens are 7, etc.

r = distance between charged particles which can be approximated by the Period – two atoms in the same period have **approximately** the same atomic radius. Na (Period 3) is smaller than K (Period 4) but similar in size to Al (also Period 3.)

B. Applying Coulomb's Law to Ionic Compounds

E = *lattice energy*, the energy needed to separate oppositely charged ions. The higher the lattice energy, the stronger the ionic bond. The stronger the ionic bond the less soluble in water at a given temperature, since the ions must separate/dissociate from one another and attach to water in order to dissolve.

Q_1 = charge of positive ion

Q_2 = charge of negative ion
r = bond length, the distance between the nuclei of the 2 ions – can also be approximated by the Period. (*Remember to use the Period of the element that is isoelectronic with the ion! Na is in Period 3 and has 3 occupied energy levels. Na+ has lost an electron. It has 10 electrons and is isoelectronic with Ne in Period 2. Na+ has only 2 occupied energy levels.*)

So, let's start with some simple questions which we will later use Coulomb's Law to answer. Get out a Periodic Table. **Nothing else** – no text, no tables, no calculator.

1) Which atom is larger, Na or K? Explain why.

2) Which atom is larger, Na or Al? Explain why.

3) Which is larger, Na or Na^+ ? Explain why.

4) Which is larger, Br or Br^- ? Explain why.

5) Which has a higher first ionization energy, Li or Na? Explain why.

6) Which has a higher first ionization energy, Na or Al? Explain why.

7) Which has a stronger ionic bond, LiCl or NaCl? Explain why.

8) Which has stronger ionic bond, NaCl or $AlCl_3$? Explain why.

9) Which is more soluble (will produce a more concentrated saturated solution) in 80°C water, LiCl or NaCl? Explain why.

10) Which is more soluble in 80°C water, NaCl or $AlCl_3$? Explain why.

11) Why is Na_2O soluble in water while Al_2O_3 is not?

A little joke that is probably more true than a joke...

If in doubt... the answer is probably Coulomb's Law! Ha!

$$F \propto \frac{Q_1 Q_2}{r^2}$$