How to Answer Periodic Trends Free Response Questions

Justifying all of the trends on the periodic table can be simplified using these two generalizations:

1. Use ***number of protons*** *(or Z_{eff})* to justify trends **across a period**.
2. Use **increased distance (greater value of *n*)** to justify trends **down a group**.

How to Earn Full Points on Periodic Trends Problems

Follow these three steps EVERY time you answer a periodicity question!

1) Locate *both* elements on the periodic table and **state** the principal energy level (*n*) and the sublevel containing the valence electrons for *each* element.
2) Do they have the same or different _n_ values?
3) If same *n*: argue with number of _protons_; if different *n*: argue with *n* vs. *n* _(distance)_.
   ↑ between nucleus & valence e^-

REMEMBER: a trend is not an explanation!

Simply identifying a trend (atomic radius decreases as you move from left to right across a period, electronegativity decreases as you move down a column, etc) earns _∅_ points!

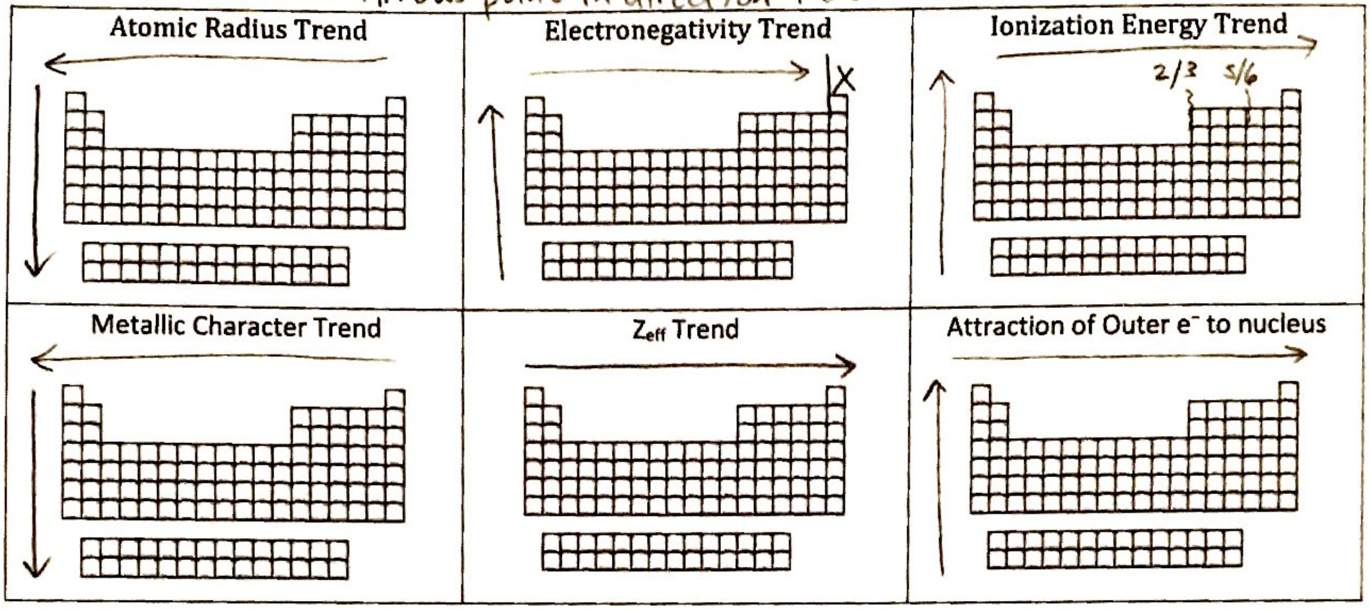
Avoid Losing Easy Points

1. When explaining, you must refer to **ALL** species (atoms, ions) referenced in the question, or you will not get full credit.
2. Read the question: justify with "principles of atomic structure" or "Coulomb's Law" (it will always be one or the other ☺).

Specific Question Types

1. Comparisons between _isoelectronic_ (same # e^-) species: explain with number of p^+
   a. Isoelectronic species with _more_ protons are **SMALLER** because the valence electrons are **MORE** attracted to and thus **CLOSER** to the nucleus.
   b. Isoelectronic species with _less_ protons are **LARGER** because the valence electrons are **LESS** attracted to and thus **FARTHER** from the nucleus.
2. Comparisons between an atom and its ion/ions of the same atom, _same_ n: explain with **e^-/e^- repulsion**
   a. Positively charged cations are **SMALLER** than the neutral atom because of _↓_ e^-/e^- repulsion, thus valence electrons are **CLOSER** to the nucleus.
   b. Negatively charged anions are **LARGER** than the neutral atom because of _↑_ e^-/e^- repulsion, thus valence electrons are **FARTHER** from the nucleus.
3. Comparisons between an atom and its ion/ions of the same atom, _different_ n: explain with **distance**
   a. If a species has their outermost electrons on a lower energy level (n), their valence electrons are _closer_ to and thus _more_ attracted to the nucleus.

What are the trends to know? Arrows point in direction trend increases!



- **Atomic radius** (size of atom): distance between the nucleus and valence electrons.
- **Ionic radius:** distance from the nucleus to valence electrons in a charged ion.
- **Metallic character** can be defined as how easily an atom loses an electron. This is exactly the opposite of the trend for first ionization energy: ↑ IE = ↓ metallic character.
- **Reactivity** depends on whether the element reacts by losing electrons (metals) or gaining electrons (nonmetals).
  - Metals are MORE reactive as you move down a column: because metals **lose** electrons as they react, **LESS** attraction between valence electrons and nucleus results in a more reactive metal.
  - Non-metals are LESS reactive as you move down a column: because non-metals **gain** electrons as they react, **LESS** attraction between valence electrons and nucleus results in a less reactive non-metal.
- **Electronegativity:** attraction of an atom for pair of valence level electrons in a covalent bond with another atom. Think of the atoms as playing "tug of war" with their valence shell electrons!
- **Ionization Energy (IE):** energy required to remove an electron from a gaseous atom or ion. **Higher** attraction between nucleus and electron = **harder** to remove electron = ↑ ionization energy
  - 1st Ionization Energy: (IE_1) energy required to remove the first (highest energy level) electron
  - 2nd Ionization Energy: (IE_2) energy required to remove the second highest energy electron
  - Each additional electron requires **MORE** energy to remove than the previous one, so: $IE_1 < IE_2 < IE_3$ etc.

Note: You can identify an element by being given a table showing the pattern of successive ionization energies.

Successive Ionization Energies (kJ/mol)

First	Second	Third	Fourth	Fifth
801	2,426	3,660	24,682	32,508

3 valence e⁻, b/c 4th e⁻ requires significantly more energy to remove than first 3 e⁻, so this must be an element from the 3rd group (the boron family).