Inorganic Cumulative Exam
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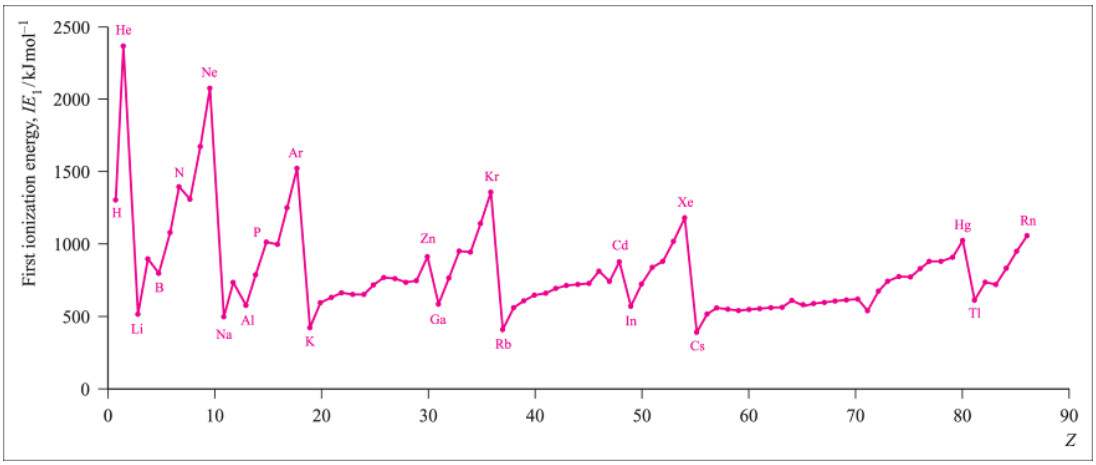
Consider the following data for first ionization energy (IE_1) as a function of atomic number (Z).



1. Provide a definition for first ionization energy (IE_1).
2. Within each row of the periodic table, the general trend is for IE_1 to increase from left to right. For example, F and Ne have larger IE_1 values than Li and Be. Explain this trend.
3. Within each column of the periodic table, the general trend is for IE_1 to decrease from top to bottom. For example, He and Ne have larger IE_1 values than Ar and Kr. Explain this trend.
4. There are certain anomalies that break these trends. For example, explain why the Group 13 elements (e.g. B, Al, Ga) have lower IE_1 values than the elements immediately to their left in each row.
5. Similarly, explain why the Group 15 elements (e.g. N, P, As) have higher IE_1 values than the corresponding Group 16 elements (e.g. O, S, Se) in each row.
6. Atomic radii follow similar periodic trends. How does atomic radius generally vary across each row of the periodic table? And down each column? Explain both trends.
7. Similarly, atomic radii for each element have clear trends vs. charge. Rank the following ions in order of atomic radius: Mn^{2+}, Mn^{3+}, Mn^{4+}. Explain the trend.

Consider the following data for ammonia (NH_3) and phosphine (PH_3).

Property	Boiling point	H-E-H bond angle	Inversion barrier	pK_a of EH_4^+
NH_3	-33°C	107°	155 kJ/mol	9.25
PH_3	-83°C	93°	25 kJ/mol	-14

8. Explain why PH_3 has a lower boiling point than NH_3
9. Explain why PH_3 has a smaller bond angle than NH_3
10. Explain why PH_3 has a lower inversion barrier than NH_3.
11. Explain why PH_4^+ has a significantly lower pK_a than NH_4^+, i.e. why NH_3 is a Brønsted base and PH_3 is not.

12. Use MO analysis to provide S-S bond orders for the following molecules/ions: S_2, S_2^-, S_2^{2-}. Show your work.