

1.2.2 Periodic data and structure

Name: _____ Class: _____ Date: _____

Total: 26 marks

KEY WORDS ionisation energy • orbital

Objective

Use configurations, graph axes and structure models to interpret periodic data through krypton. Original supplied data and marking guidance; this is not an official paper.

1 Key knowledge and worked examples

■ Read the subshell and the axis

The s, p and d blocks identify the subshell receiving the differentiating electron. K ends in $4s^1$ and is s-block; Sc ends in $3d^14s^2$ and is d-block; As ends in $4p^3$ and is p-block. Helium is s-block by its $1s^2$ configuration although it is placed with the noble gases.

On a linear energy axis, a rise of 100 kJ mol^{-1} has the same vertical distance everywhere. On a $\log_{10}$ axis, equal distances represent equal energy ratios: changing from 3.0 to 3.3 corresponds to a factor of about 2. Use $\log_{10}(E / \text{kJ mol}^{-1})$ so the logarithm refers to the numerical energy in the specified unit. A logarithmic plot preserves the order of values.

Do not explain every periodic property with nuclear charge alone. Melting depends on the particles, bonding and structure; removing one gaseous electron is a different process from melting a solid.

2 Practice

2.1 Classify K, Sc, As and He into s, p or d blocks using the configurations above. Explain why helium's noble-gas column does not make it a p-block element. [4]

3 Exam-style questions

3.1 Use your graphs to identify three decreases that mark the start of a new occupied outer shell. Explain the general decrease using distance, shielding and nuclear charge. State one advantage of the logarithmic representation. [4]

3.2 Explain why the first-ionisation energy falls from Be to B and from N to O, although nuclear charge increases in each case. Give the relevant outer configurations. [4]

3.3 Classify Li/Be, B/C, N₂/O₂/F₂ and Ne by their Period-2 solid structures. Explain why carbon has a much higher melting temperature than nitrogen, and why melting nitrogen does not break its N≡N bonds. [5]

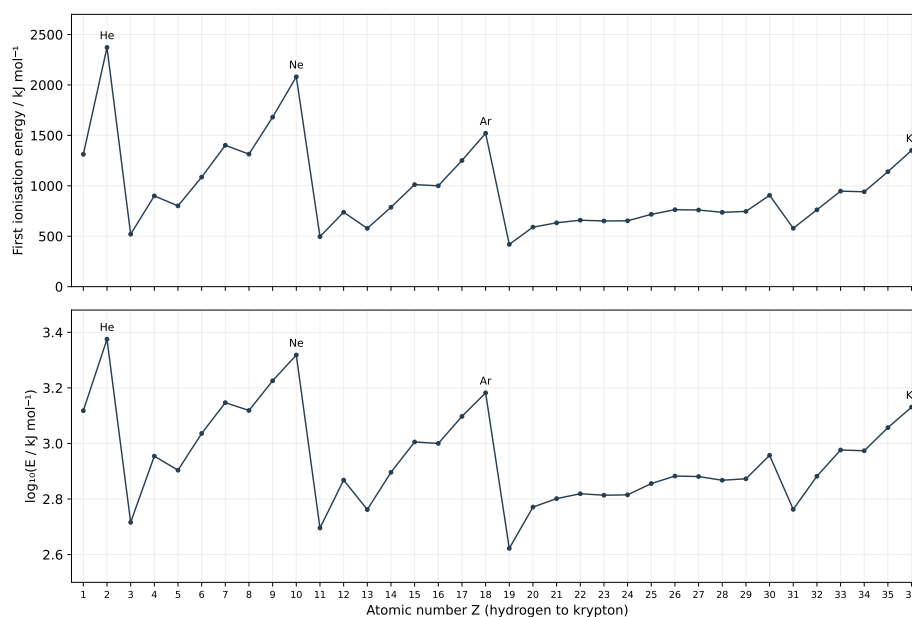
3.4 A student describes the first 36 elements as a smooth rise interrupted only after noble gases. Evaluate this claim using two counterexamples from the table. Explain why this graph alone cannot predict every element's melting temperature. [3]

Solutions

Original authored marking guidance; accept equivalent reasoning and sensible plotting accuracy.

2.1 K s-block, Sc d-block and As p-block. He is s-block because its electrons occupy $1s^2$; the column reflects its full outer shell and chemical behaviour, not a p-electron configuration.

2.2



Linear axes labelled with Z and energy/unit and a consistent scale; all linear points correctly placed. Log axis labelled and scaled, all transformed points correctly placed. He, Ne, Ar and Kr identified as the noble-gas peaks; same ordered data on both plots with no substitution of successive ionisations for different atoms. Accept a correctly labelled logarithmically scaled energy axis.

3.1 $\text{He} \rightarrow \text{Li}$, $\text{Ne} \rightarrow \text{Na}$ and $\text{Ar} \rightarrow \text{K}$. The new outer shell puts the electron further from the nucleus with increased shielding; this outweighs the increase in nuclear charge, so less energy removes it. A log axis compresses the large numerical range and makes proportional changes easier to compare.

3.2 Be $[\text{He}]2s^2$; B $[\text{He}]2s^22p^1$: the B electron is removed from the higher-energy 2p sub-shell, outweighing increased nuclear charge. N $[\text{He}]2s^22p^3$ has singly occupied p orbitals; O $[\text{He}]2s^22p^4$ has a first pair, whose repulsion makes one electron easier to remove. No new occupied shell is added in these comparisons.

3.3 Li/Be metallic; B/C giant covalent; $\text{N}_2/\text{O}_2/\text{F}_2$ simple molecular and Ne monatomic. Carbon melting requires overcoming many strong covalent bonds in its giant structure. Melting nitrogen overcomes attractions between N_2 molecules, retaining the covalent triple bonds inside each molecule. The diagram of a molecule does not imply a giant covalent lattice.

3.4 Valid internal decreases include $\text{Be} \rightarrow \text{B}$, $\text{N} \rightarrow \text{O}$, $\text{Mg} \rightarrow \text{Al}$, $\text{P} \rightarrow \text{S}$, $\text{Ti} \rightarrow \text{V}$, $\text{Fe} \rightarrow \text{Co}$, $\text{Co} \rightarrow \text{Ni}$, $\text{Zn} \rightarrow \text{Ga}$ and $\text{As} \rightarrow \text{Se}$. Melting involves the solid's bonding/structure and attractions be-

tween its particles, rather than removal of one electron from gaseous atoms; first ionisation alone does not determine it.