ANSWER KEY & MARKING SCHEME · CBSE CLASS 11

Classification of Elements and Periodicity in Properties

Chemistry · Chapter 3 · Use this with the Board Paper · Companion to Quick Drill

HOW TO USE

Attempt the Board Paper first (closed-book, full time). Then come here. For 2-mark+ questions, compare your answer to the model. For 3-4 mark questions, also consult the **Topper Templates** below — these show the exact step-by-step structure that scores full marks per CBSE marking-scheme conventions.

MODEL ANSWERS · BOARD PAPER

Section A — Objective (5 × 1 = 5 marks)

Q1. **The modern periodic law states that properties of elements are a periodic function of their ____. [1 mark]**

Ans: Atomic number (Z). (Moseley, 1913.)

Q2. **Write the IUPAC name and symbol for the element with Z = 116. [1 mark]**

Ans: Digits 1-1-6 → un-un-hex-ium → Ununhexium, symbol Uuh. (Now permanently Livermorium, Lv.)

Q3. **Among Na, Mg, Al, Si in period 3, the element with the smallest atomic radius is ____. [1 mark]**

Ans: Si (smallest of the four; radius decreases across period: Na 186 > Mg 160 > Al 143 > Si 117 pm).

Q4. **The block in which the last electron enters the (n-2)f subshell is the ____ block. [1 mark]**

Ans: f-block (lanthanides + actinides).

Q5. **On the Pauling scale, the electronegativity of fluorine is ____. [1 mark]**

Ans: 4.0 (the maximum value on the Pauling scale).

Section B — Short Answer (3 × 2 = 6 marks)

Q6. **State the modern periodic law. How does it differ from Mendeleev's periodic law? [2 marks]**

Ans: Modern law (Moseley, 1913): 'Properties of elements are a periodic function of their atomic numbers.' Mendeleev's law (1869) used atomic MASS as the basis. The shift to atomic number resolved anomalies like Te before I (where mass order failed but property order matched atomic number).

Q7. **Arrange the following in increasing order of atomic radius: F, Cl, Br, I. Give a brief reason. [2 marks]**

Ans: Order: F (64 pm) < Cl (99 pm) < Br (114 pm) < I (133 pm). Reason: down a group, a new principal shell is added each period; the increase in n outweighs the increase in Z due to shielding by inner electrons.

Q8. **Predict the period, group and block of the element with atomic number Z = 24. [2 marks]**

Ans: Configuration: Cr (Z=24) = [Ar] 3d^5 4s^1 (anomalous, half-filled 3d^5 stability). Highest n = 4 → Period 4. Last e- in 3d → d-block. Group = (n-1)d + ns = 5 + 1 = 6. Hence Period 4, Group 6, d-block.

Section C — Short Explain (3 × 3 = 9 marks)

Q9. **Explain why the first ionisation enthalpy of nitrogen (1402 kJ/mol) is greater than that of oxygen (1314 kJ/mol). [3 marks]**

Ans: (i) Configurations: N (Z=7) = [He] 2s^2 2p^3; O (Z=8) = [He] 2s^2 2p^4. (ii) N has a half-filled 2p^3 arrangement — all three 2p orbitals singly occupied. This gives extra stability via symmetric distribution and maximum exchange energy. Removing an electron from N disrupts this stable configuration → energetically costly. (iii) For O (2p^4), removing one electron yields the stable 2p^3 half-filled state → energetically favoured. Hence IE_1(N) > IE_1(O) despite Z(O) > Z(N).

Q10. Explain why electron gain enthalpy of fluorine is less negative than that of chlorine. [3 marks]

> **Ans:** (i) Δ_egH(F) = -328 kJ/mol; Δ_egH(Cl) = -349 kJ/mol. Cl is MORE negative (releases more energy on gaining an electron). (ii) F has a very small valence shell (n=2, 2p). The 7 valence electrons are crowded. Adding an extra electron forces high inter-electronic repulsion in this small region. (iii) Cl's valence shell is the larger 3p; repulsion on the incoming electron is much smaller → more net energy released. Hence |Δ_egH(Cl)| > |Δ_egH(F)|.

Q11. Arrange the following isoelectronic species in increasing order of ionic radius, with reasoning: O^2-, F^-, Na^+, Mg^2+, Al^3+. [3 marks]

> **Ans:** (i) All five species have 10 electrons (Ne configuration) — they are isoelectronic. (ii) Rule: among isoelectronic species, the one with HIGHER nuclear charge Z pulls the same number of electrons more tightly, giving a SMALLER radius. (iii) Z values: O=8, F=9, Na=11, Mg=12, Al=13. Hence increasing radius: Al^3+ (53 pm) < Mg^2+ (72 pm) < Na^+ (102 pm) < F^- (133 pm) < O^2- (140 pm).

Section D — Long Answer (1 × 5 = 5 marks)

Q12. An element X has atomic number 25. (a) Write its complete electronic configuration. (b) Predict its period, group, and block. (c) Comment on its expected magnetic behaviour. (d) Predict whether it is a metal, non-metal, or metalloid, with justification. (e) Suggest one common oxidation state shown by this element in its compounds. [5 marks]

> **Ans:** (a) Z=25 → 1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2 = [Ar] 3d^5 4s^2 (1 mark). (b) Highest n = 4 → Period 4. Last e- in 3d → d-block. Group = (n-1)d + ns = 5 + 2 = 7. Element is manganese, Mn (1 mark). (c) Has 5 unpaired electrons in 3d^5 → strongly paramagnetic (1 mark). (d) It is a METAL — transition metals in the d-block are typically hard, lustrous, good conductors of heat and electricity; Mn has low IE and forms cations (1 mark). (e) Common oxidation state of Mn is +2 (loses two 4s electrons → [Ar] 3d^5, half-filled stable). Other states +4, +6, +7 (in MnO_2, MnO_4^2-, MnO_4^-) are also important (1 mark).

Section E — Application / Higher-Order (1 × 5 = 5 marks)

Q13. (a) Define electronegativity. How does it differ from electron gain enthalpy? (b) Explain why lithium shows diagonal relationship with magnesium, giving any TWO common properties shared by Li and Mg. (c) State why 2nd-period elements show anomalous behaviour compared to heavier members of their groups. [5 marks]

> **Ans:** (a) Electronegativity (EN) = the tendency of an atom IN A BOND to attract the shared pair of electrons. It is a relative dimensionless number (Pauling scale, F=4.0 max). Electron gain enthalpy (Δ_egH) = the ENERGY released when an isolated GASEOUS atom gains an electron (units kJ/mol). EN applies to bonded atoms; EGE applies to isolated atoms (2 marks). (b) Li and Mg show diagonal relationship because going down (Li→Na) decreases EN/increases size, while going right (Na→Mg) increases EN/decreases size; the two effects cancel along the diagonal → Li and Mg have similar polarising power (charge/radius) and similar EN. Shared properties (any two): (i) both react directly with N_2 to form nitrides (Li_3N, Mg_3N_2); (ii) both form normal oxides (Li_2O, MgO) rather than peroxides/superoxides; (iii) both form covalent organometallic compounds (LiR, MgR_2) (2 marks). (c) 2nd-period elements (Li-Ne) have only n=2 valence (2s + 2p, no d-orbitals). Hence (i) small atomic size, (ii) high electronegativity, (iii) maximum covalency restricted to 4 (e.g., CCl_4 not CCl_5), (iv) no expansion of octet possible — unlike heavier members which can use d-orbitals (e.g., PCl_5, SF_6) (1 mark).

★ TOPPER ANSWER TEMPLATES — 5 TEMPLATES · MEMORISE THE FORMAT

★ TOPPER TEMPLATE — Why is IE_1 of N greater than O (2-3 marks)

85% of papers

Step 1 [1 mark]	**Write configurations**	N (Z=7): 1s^2 2s^2 2p^3 — three 2p electrons singly occupy each of 2p_x, 2p_y, 2p_z (half-filled). O (Z=8): 1s^2 2s^2 2p^4 — one pair in one 2p orbital, two unpaired.
Step 2 [1 mark]	**Identify the source of anomaly**	Half-filled 2p^3 of N has EXTRA STABILITY due to symmetric distribution and maximum exchange energy. Removing an electron from N requires breaking this stability.
Step 3 [1 mark]	**Conclusion**	Removing one electron from O (2p^4) gives the stable 2p^3 configuration — energetically favourable. Hence IE_1(N) = 1402 kJ/mol > IE_1(O) = 1314 kJ/mol despite O having higher Z.

COMMON LOSS OF MARKS:

- Saying only 'N is more stable' without explaining half-filled symmetry/exchange
- Forgetting to mention that O loses e- to ATTAIN the half-filled state
- Quoting wrong values (always check direction: N > O)

★ TOPPER TEMPLATE — Explain atomic radius trend across period / down group (3 marks)

80% of papers

Step 1 [1 mark]	**Across a period — DECREASES**	Across a period (left → right), nuclear charge Z increases by 1 per element while electrons are added to the SAME shell. Effective nuclear charge Z_eff rises; the electron cloud is pulled in. Example: Na (186 pm) → Cl (99 pm) across period 3.
Step 2 [1 mark]	**Down a group — INCREASES**	Down a group (top → bottom), a new principal shell is added with each row. The increase in n outweighs the increase in Z because inner electrons SHIELD outer ones. Example: Li (152 pm) → Cs (262 pm) down group 1.
Step 3 [1 mark]	**Define + note**	Atomic radius = half the distance between two nuclei in a homonuclear bond (covalent radius). For metals: half of nearest-neighbour distance in crystal (metallic radius). For noble gases: van der Waals radius (always largest of the three types).

COMMON LOSS OF MARKS:

- Confusing 'shielding' with 'screening' (they're the same) — just be consistent
- Saying radius increases across period (REVERSE!)
- Forgetting to define which radius (covalent / metallic / vdW)

★ TOPPER TEMPLATE — Arrange isoelectronic species in order of size (2-3 marks)

65% of papers

Step 1 [1 mark]	**Identify the species + electron count**	Example: O^2-, F^-, Na^+, Mg^2+, Al^3+. All have 10 electrons (Ne configuration). They are ISOELECTRONIC.
Step 2 [1 mark]	**Apply the rule: higher Z → smaller radius**	Among isoelectronic species, the one with HIGHER nuclear charge pulls the same number of electrons more tightly. Z values: O=8, F=9, Na=11, Mg=12, Al=13.
Step 3 [1 mark]	**Write the order**	Increasing radius: Al^3+ (53 pm) < Mg^2+ (72 pm) < Na^+ (102 pm) < F^- (133 pm) < O^2- (140 pm). ✓

COMMON LOSS OF MARKS:

- Forgetting to state 'isoelectronic' (you lose the framing mark)
- Reversing the order (cations are SMALLER than anions when isoelectronic)
- Using neutral atom radii instead of ionic radii

★ TOPPER TEMPLATE — Why EGE of F is less negative than Cl (2-3 marks)

55% of papers

Step 1 [1 mark]	**State the data**	Δ_eg H (F) = -328 kJ/mol; Δ_eg H (Cl) = -349 kJ/mol. Cl is MORE negative — more energy released when Cl gains an electron — anomalous against the 'across-period more negative' trend.
Step 2 [1 mark]	**Identify the cause — small 2p shell**	F has a very small valence shell (n=2, 2p). The incoming electron enters an already crowded region. Inter-electronic repulsion is high, which offsets much of the nuclear attraction.
Step 3 [1 mark]	**Cl has larger 3p — less repulsion**	Cl's incoming electron enters the larger 3p shell where it has more room. Repulsion is lower, so the net energy released is greater. Hence Cl > F in magnitude of EGE. Trend in group 17 magnitude: Cl > F > Br > I.

COMMON LOSS OF MARKS:

- Saying 'F is more electronegative so EGE is more negative' — WRONG, it's less negative
- Forgetting to mention 'small size' / 'electron-electron repulsion'
- Quoting wrong sign convention (EGE values are NEGATIVE for energy released)

★ TOPPER TEMPLATE — Predict period/group/block from configuration (2 marks)

60% of papers

Step 1 [1 mark]	**Write the configuration + identify last subshell**	Example: Z = 25 (Mn). Configuration: 1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2 = [Ar] 3d^5 4s^2. Last electron enters 3d → d-block.
Step 2 [1 mark]	**Period + Group + Block**	Period = highest n = 4. Group = (n-1)d electrons + ns electrons = 5 + 2 = 7. Block = d. Hence Mn is in Period 4, Group 7, d-block (transition element).

COMMON LOSS OF MARKS:

- Counting only ns electrons for a d-block element (must add (n-1)d too)
- Using old 1-8 + I-VIII group numbering instead of modern 1-18
- Forgetting that period = HIGHEST n (not n of last-filled subshell — for d-block last filled is (n-1)d but period is n)

MARKING SCHEME — GENERAL NOTES

- Configurations: any equivalent notation acceptable ([Ar] 3d^5 4s^2 or full 1s^2... or with subshell-level diagrams).
- Trend explanations: full marks require (i) statement of trend, (ii) underlying reason (Z_eff / shielding / shell number), (iii) at least one numerical or example illustration.
- Anomaly questions (N>O, Be>B, F vs Cl): full marks require explicit mention of half-filled/full-filled stability OR small-shell e-e repulsion.
- Isoelectronic ordering: students MUST state 'isoelectronic' explicitly and quote Z values to justify the order.
- Position prediction: deduct 0.5 marks if group is given in old I-VIII numbering without 1-18 equivalent.
- Allow internal choice for one Section-C and the Section-D / Section-E long answers as per CBSE convention.
- Numerical / unit accuracy: small variations in quoted radius/IE values (within ±5%) acceptable if reasoning is correct.