2023 Ch H2 Q1

Section: Chemical Changes and Structure

Topic: Periodicity

Question Summary

(a) (i) Explain the increase in first ionisation energy across elements d to k.
(ii) Identify a group 7 element from a–m.
(iii) Explain the large increase between the 1st and 2nd ionisation energies of sodium and calculate ΔH for $Na^{+} \rightarrow Na^{3+} + 2e^{-}$.
(b) (i) Define electronegativity.
(ii) Explain why electronegativity decreases down a group.
(iii) Identify the best reducing agent among the group 2 elements.

Worked Solution

According to the SQA Marking Instructions:

(a)(i) Across d to k, atomic number increases → more protons in the nucleus. Nuclear charge increases, pulling electrons

closer.
Atomic radius decreases, shielding remains fairly constant.
Therefore, ionisation energy increases across the period.

(a)(ii) Group 7 elements are the halogens (F, Cl, Br).
From the ionisation energy data, the large increase after element j indicates element k is a halogen.

(a)(iii) First IE of Na = 496 kJ mol^{-1}, second IE = 4562 kJ mol^{-1}.
The large jump occurs because the 2nd electron is removed from a full inner shell.
Energy change for $Na^{+} \rightarrow Na^{3+} + 2e^{-}$ is $IE_2 + IE_3 = 4562 + 6910 = 11{,}472$ kJ mol^{-1}.

(b)(i) Electronegativity is the ability of an atom to attract the bonding electrons in a covalent bond.

(b)(ii) Down a group, atoms get larger (more electron shells).
Increased shielding reduces attraction between nucleus and bonding electrons.

Therefore, electronegativity decreases.

(b)(iii) The best reducing agent is the one most easily oxidised (loses electrons most easily).
In group 2, this is the lowest element, barium.

Final Answer

(a)(i) Ionisation energy increases across d–k due to increased nuclear charge.

(a)(ii) Element k.

(a)(iii) Large increase due to removal from inner shell; ΔH = 11,472 kJ mol^{-1}.

(b)(i) Electronegativity = attraction for bonding electrons.

(b)(ii) Decreases down a group due to increased shielding.

(b)(iii) Best reducing agent = barium.

Revision Tips

• Ionisation energy increases across a period (more protons, smaller radius).
• Large jumps in IE show removal from a new shell.
• Electronegativity decreases down groups.
• Group 2 reactivity increases down the group: Ba is the strongest reducing agent.