1.2 The periodic table

Name: _____ Class: _____ Date: _____ **Total: 36 marks**

KEY WORDS group • displacement • alkali metals

Objective

Explain periodic-table position, group trends in 0, 1 and 7, and the table's development. Original questions for spec statement 4.1.2.

1 Key knowledge and worked examples

Elements are ordered by **atomic (proton) number**; main Groups 1–7 have the same number of **outer-shell electrons** within each group. Group 0 has full outer shells: helium has two electrons, while the others have eight.

Development: early tables used **atomic weight** – incomplete and sometimes misplaced elements. **Mendeleev** left **gaps** for undiscovered elements and swapped some orders; the predictions were confirmed. **Isotopes** explained why atomic-weight order sometimes failed (average masses can invert).

Metals form positive ions – left and lower; **non-metals** do not characteristically form positive ions – right and upper; they can gain or share electrons.

- **Group 0**: full outer shells → **unreactive**; boiling points increase down.
- **Group 1** (Li, Na, K): 1 outer electron; react with oxygen, chlorine and water ($2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$). Reactivity **increases down** – the outer electron is further out and lost more easily.
- **Group 7** (halogens, diatomic): 7 outer electrons; melting/boiling points increase down; reactivity **decreases down** – an outer electron is gained less easily. A more reactive halogen **displaces** a less reactive one: $Cl_2 + 2\ KBr \rightarrow 2\ KCl + Br_2$.

Worked example (3 marks). Explain why potassium reacts more vigorously with water than sodium.

Both lose their one outer electron in the reaction; in potassium the outer electron is further from the nucleus, so the attraction is weaker; the electron is lost more easily, so the reaction is faster/more vigorous.

2 Practice

2.1 Why do elements in the same group have similar chemical properties? [1]

2.2 Give the formula of the compound formed when lithium reacts with chlorine. [1]

2.3 Predict whether astatine is more or less reactive than iodine, with a reason. [2]

3 Exam-style questions

3.1 Describe how Mendeleev arranged his periodic table and why his predictions mattered. [5]

3.2 Chlorine is added to potassium bromide solution. Write the equation and explain, in terms of electrons, why this reaction happens. [4]

3.3 Explain why the noble gases are unreactive and why their boiling points increase down the group. [4]

3.4 Two supplied element records are X:atomic number18, relative atomic mass40.0; Y:atomic number19, relative atomic mass39.1. Give their modern order and explain why ordering only by average atomic mass would reverse it. What does isotope knowledge contribute to the explanation? [4]

3.5 Describe the products of lithium reacting separately with oxygen, chlorine and water. Balance $Li + O_2 \rightarrow Li_2O$ and $Li + H_2O \rightarrow LiOH + H_2$. Predict how potassium's water reaction compares with lithium's and explain using electron arrangements. [6]

3.6 Halogen A displaces halogen B from aqueous B^-, but B does not displace A from A^-. Both displace iodine from iodide. Rank A, B and iodine by reactivity. Explain why iodine is diatomic but forms an ionic compound with sodium. Give the equation for chlorine displacing iodine from potassium iodide. [5]

3.7 Helium has 2 electrons and argon has 18. Explain why both are in Group 0 even though they have different outer-electron numbers. Predict which has a higher boiling point and state how their particles are represented. [4]

Solutions

2.1 They have the same number of electrons in their outer shell.

2.2 LiCl.

2.3 Less reactive; astatine has more occupied shells than iodine, so shielding/distance weaken attraction for an incoming electron.

3.1 Mendeleev ordered elements (mostly) by atomic weight, putting elements with similar properties in the same group; he left gaps for elements he believed were undiscovered and predicted their properties; when those elements were found with the properties predicted, his table and periodic law were accepted.

3.2 Cl_2 + 2 KBr → 2 KCl + Br_2. Chlorine is more reactive than bromine because it gains an electron more easily – a stronger attraction for the outer shell being closer to the nucleus; so chlorine oxidises bromide ions to bromine molecules.

3.3 Their atoms have stable (full) outer shells – eight electrons, or two for helium; so they do not readily lose, gain or share electrons. Going down the group, relative atomic mass and the number of electrons increase; intermolecular forces grow stronger, so more energy is needed to boil the liquid – boiling points rise.

3.4 X then Y because $18 < 19$ and modern order uses proton number. $39.1 < 40.0$ would put Y first by mass. Relative atomic mass is a weighted isotope average, so it need not rise strictly with proton number. Isotopes change neutrons/mass, not element identity.

3.5 Products: lithium oxide; lithium chloride; lithium hydroxide plus hydrogen. $4Li + O_2 \rightarrow 2Li_2O$; $2Li + 2H_2O \rightarrow 2LiOH + H_2$. Potassium reacts more vigorously; its outer electron is farther from the nucleus/more shielded, so is lost more easily. Use supplied oxide formula rather than claiming all alkali-metal oxygen products are identical.

3.6 A > B > iodine. Iodine element has I_2 molecules containing two iodine atoms; with sodium it forms Na^+/I^- ions in NaI. $Cl_2 + 2KI \rightarrow 2KCl + I_2$. An elemental molecule and a metal-halide compound have different structures.

3.7 Helium's first shell is full with 2; argon is 2,8,8 with a full outer shell. Argon has the higher boiling point from the Group 0 trend. Both gases are monatomic, separate atoms rather than diatomic molecules.