08 The Periodic Table and Periodicity

Set B **Answer key**

A Competition questions

24 MARKS

1 **C** Z forms the largest cation. [1]

The big jump in successive ionisation energies shows the number of outer electrons. V jumps after IE_4 (silicon), W after IE_2 (magnesium, an alkaline earth metal), Y after IE_1 (sodium) and Z after IE_3 (aluminium). X shows no jump in the first five, so it lies near the end of the period.

Z is aluminium, and Al^{3+} is the smallest of these cations, not the largest, so C is false. X has the greatest nuclear charge of the five and the same number of shells, so it has the smallest radius.

2 **B** It can form a chloride with the formula QCl_5. [1]

The big jump is after the 5th ionisation energy, so Q has 5 valence electrons and is in Group 15. Below Period 2 it can expand its octet and form QCl_5.

A Group 15 oxide is acidic, not basic. The atomic numbers of Group 15 elements (7, 15, 33, 51, 83) are odd. QCl_3 is pyramidal, not trigonal planar.

3 **D** Sodium's electron is closer to the nucleus. [1]

Na^+ must lose an electron from the inner 2p subshell, close to the nucleus and little shielded.

Mg^+ still has a 3s electron in the outer shell, which is far easier to remove.

4 **B** 1 and 2 only [1]

Rb^+ has lost its outer shell, so it is smaller than the atom. Br^- has an extra electron, so it is larger.

Br^- and Rb^+ have the same electrons, but Br has 35 protons and Rb 37, so Br^- is the larger ion.

5 **B** melting points decrease [1]

Melting points rise from sodium to silicon and only then fall.

The other three are true trends.

6 **A** R, Q, P, S [1]

R is sodium, Q is silicon (SiO_2), P is phosphorus or sulfur (acidic oxide) and S is argon.

Na (11), Si (14), P or S (15 or 16), Ar (18).

7 **A** row A [1]

SO_3 gives sulfuric acid (pH 1). SiO_2 is insoluble (pH 7).

MgO is sparingly soluble (pH 9) and Na_2O gives NaOH (pH 13).

8 **D** acidity decreases [1]

The acidity increases across the period: NaCl gives pH 7 and PCl_5 pH 2.

$SiCl_4 + 4H_2O \rightarrow SiO_2 \cdot 2H_2O + 4HCl$, Al_2O_3 is amphoteric, and $2NaOH + H_2SO_4$ gives neutral Na_2SO_4.

9 **A** Z, X, W, Y [1]

Z is sodium (Na_2O), X aluminium (amphoteric), W silicon (SiO_2 needs concentrated alkali) and Y phosphorus or sulfur.

In order: Na, Al, Si, then P or S.

10 **A** X < Y < Z [1]

Z is sodium, Y aluminium and X a non-metal further right.

Atomic radius decreases across the period, so X is smallest and Z largest.

11 **C** G, F, E, H [1]

G, with the lowest electronegativity, is furthest left (sodium). F is aluminium. H, the smallest atom, is furthest right.

E has an acidic chloride and lies between: G, F, E, H.

12 **C** the oxide gives an acidic solution [1]

A, B and D describe aluminium: a conducting metal, $AlCl_3$ hydrolyses to pH 3, and $Al(OH)_3$ dissolves in excess alkali.

Aluminium oxide is insoluble in water, so C does not fit.

13 **A** the oxide dissolves in dilute NaOH [1]

B, C and D describe silicon: $SiCl_4$ is a liquid that hydrolyses to pH 2, and SiO_2 is giant covalent.

SiO_2 reacts only with hot concentrated alkali, so A does not fit.

14 **A** 1 only [1]

Z is silicon, a solid.

SiO_2 is insoluble in water, and silicon forms only $SiCl_4$.

15 **B** It is amphoteric. [1]

Y is silicon, so X is aluminium.

Aluminium oxide, Al_2O_3, is an amphoteric, giant ionic solid.

16 **C** N, O, M [1]

N has a basic oxide (a metal on the left), O an amphoteric oxide (aluminium) and M an acidic oxide (a non-metal on the right).

Across a period oxides change from basic to amphoteric to acidic: N, O, M.

17 **B** reducing power decreases [1]

The two outer electrons are lost more easily down the group, so the reducing power increases.

The carbonates give a white oxide and carbon dioxide, an acidic gas, and the solutions with water become more alkaline.

18 **D** thermal stability of the carbonate [1]

The larger M^{2+} ion polarises the carbonate ion less, so the carbonate is more stable.

Charge density, electronegativity and melting point all generally decrease.

19 **B** 1 and 2 only [1]

Smaller, doubly charged ions and two delocalised electrons per atom give stronger metallic bonding.

Ionisation energy is not what holds the lattice together.

20 **A** bromine is decolourised by NaCl [1]

Bromine is less reactive than chlorine, so it cannot displace chlorine: nothing happens and the solution stays orange.

AgCl is a white precipitate, chlorine oxidises thiosulfate to sulfate (white $BaSO_4$), and chlorine displaces brown iodine.

21 **D** row D [1]

Potassium is below sodium, so it is more reactive. Lithium is less reactive.

Z displaces Y from its salt, so Z is more reactive than Y: chlorine displaces iodine from KI.

22 **B** S, R, Q, T [1]

Q displaces T, so Q is above T. Q cannot displace R, so R is above Q.

A carbonate that does not decompose belongs to a very reactive metal, so S is at the top: S, R, Q, T.

23 **A** Q is high up in the series. [1]

Only metals above carbon need electrolysis, so Q is very reactive.

R is found uncombined, so it is unreactive and below hydrogen. Q's compounds are the hardest to break down.

24 **D** Iron corrodes in place of copper. [1]

Iron is above copper in the reactivity series, so it loses electrons more readily.

In contact with copper, iron acts as the sacrificial metal and corrodes instead.