Class 11 Chemistry · Chapter 3: Classification of Elements and Periodicity in Properties

Answer key and marking scheme · 20 marks · about 40 minutes · based on NCERT

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1. An element X has atomic number 38. The element whose chemical properties would be most like those of X has the atomic number [1]

(a) 37 (b) 20
(c) 39 (d) 36

Answer: (b) Z = 38 is $[Kr]5s^2$: period 5, group 2. Z = 20 is $[Ar]4s^2$, also group 2, with the same ns^2 valence configuration and so similar properties. 37 and 39 are its neighbours in the period (groups 1 and 3), and 36 is a noble gas.

2. Which of the following elements is a metalloid? [1]

(a) germanium (b) gallium
(c) selenium (d) tin

Answer: (a) Germanium borders the zig-zag line and shows properties of both metals and non-metals. Gallium and tin are metals; selenium is a non-metal.

3. Which of the following pairs is isoelectronic? [1]

(a) Na^+ and Mg (b) O^{2-} and Cl^-
(c) N^{3-} and Ne (d) K^+ and Ne

Answer: (c) N^{3-} has 7 + 3 = 10 electrons and Ne has 10. Na^+ (10) and Mg (12), O^{2-} (10) and Cl^- (18), K^+ (18) and Ne (10) differ.

4. Moseley plotted the square root of the frequency of the characteristic X-rays of elements against another property and obtained a straight line. That property is [1]

(a) atomic mass (b) mass number
(c) atomic number (d) density

Answer: (c) The plot of $\sqrt{\nu}$ against atomic number (Z) is a straight line; against atomic mass it is not. This showed atomic number to be the more fundamental property.

5. Sulphur (atomic weight 32), selenium and tellurium (atomic weight 127.6) behave as a Dobereiner triad. The atomic weight the Law of Triads predicts for selenium is [1]

(a) 95.6 (b) 79.8
(c) 47.8 (d) 159.6

Answer: (b) In a triad the middle element's atomic weight is about half way between the other two: (32 + 127.6)/2 = 79.8. 95.6 is the difference, 47.8 half of it, 159.6 the sum.

6. Why are the lanthanoids and actinoids placed in separate rows at the foot of the periodic table? [2]

Fourteen elements in each of periods 6 and 7 fill the 4f and 5f orbitals and have very similar properties. Placing them in the main body would break the table's structure (it would need 32 columns), and keeping them apart preserves the principle that elements with similar properties stand in a single column.

- to maintain the structure of the table (1)
- to keep elements of similar properties in one column / they resemble one another (1)

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7. Why is the chemistry of the early actinoids more complicated than that of the corresponding lanthanoids? What are transuranium elements? [2]

The early actinoids can show a large number of oxidation states, and they are radioactive, many made only in nanogram quantities, so their chemistry is complicated and not fully studied. The elements after uranium (Z > 92) are called transuranium elements.

- many possible oxidation states (and radioactivity) of actinoids (1)
- transuranium: elements after uranium (1)

8. Lithium and beryllium form compounds with pronounced covalent character, while the other members of their groups form mainly ionic compounds. Give two reasons for this behaviour of the first members. [2]

The first member of a group is anomalous because of (i) its small size and large charge/radius ratio, which lets the cation distort the anion's electron cloud, and (ii) its high electronegativity compared with the rest of the group. (It also has only four valence orbitals, 2s and 2p.)

- small size / large charge to radius ratio (1)
- high electronegativity (or only four valence orbitals) (1)

9. Classify MgO, Al_2O_3 and SO_3 as basic, acidic or amphoteric, and write one equation for each to show its nature. [3]

MgO is basic: $MgO + 2HCl \rightarrow MgCl_2 + H_2O$. SO_3 is acidic: $SO_3 + H_2O \rightarrow H_2SO_4$ (or $SO_3 + 2NaOH \rightarrow Na_2SO_4 + H_2O$). Al_2O_3 is amphoteric, reacting with both acids and bases: $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$ and $Al_2O_3 + 2NaOH + 3H_2O \rightarrow 2Na[Al(OH)_4]$. The trend follows the period: basic on the left, amphoteric in the centre, acidic on the right.

- MgO basic, with equation (1)
- SO_3 acidic, with equation (1)
- Al_2O_3 amphoteric, with an equation with acid or base (1)

10. What did Moseley observe in the X-ray spectra of the elements? How did this change the Periodic Law, and what became of Mendeleev's placing of tellurium before iodine? [3]

Moseley found that a plot of $\sqrt{\nu}$ (ν, the frequency of the characteristic X-rays) against atomic number is a straight line, while the plot against atomic mass is not; atomic number is the more fundamental property. The law became: the physical and chemical properties of the elements are periodic functions of their atomic numbers. Te (Z = 52) has a lower atomic number than I (Z = 53), so ordering by Z places Te before I naturally; the anomaly disappears.

- $\sqrt{\nu}$ against Z is a straight line, not against atomic mass (1)
- Modern Periodic Law in terms of atomic number (1)
- Te (52) before I (53) follows from atomic number (1)

11. Mendeleev left a gap below silicon in his table and called the missing element eka-silicon. (a) Explain how he could predict the formulas of its oxide and chloride. (b) He predicted an atomic weight of 72 and a density of 5.5 g cm^{-3}; germanium, discovered later, has 72.6 and 5.36 g cm^{-3}. What do these figures show about his gaps? (c) What did the success of such predictions do for his Periodic Table? [3]

(a) Mendeleev relied on the similarities in the empirical formulas of the compounds of elements in a group. Silicon forms SiO_2 and $SiCl_4$, so eka-silicon would form EO_2 and ECl_4; germanium was indeed found to form GeO_2 and $GeCl_4$. (b) The predicted and found values agree closely (72 against 72.6; 5.5 against 5.36 g cm^{-3}). The gap was a real, then undiscovered element, and its properties could be foretold from its place among elements of similar properties. (c) The boldness of these quantitative predictions and their eventual success made Mendeleev and his Periodic Table famous.

- (a) EO_2 and ECl_4, from similar empirical formulas within silicon's group (1)
- (b) close agreement: the gap was an undiscovered element whose properties followed from its place in the table (1)
- (c) the success made Mendeleev and his table famous / gained it acceptance (1)