Chemical Periodicity

Q-1) What is periodicity?

> The recurrence of the same pattern in properties of elements is called periodicity.

Q-2) Patterns of atomic radii

Down the group

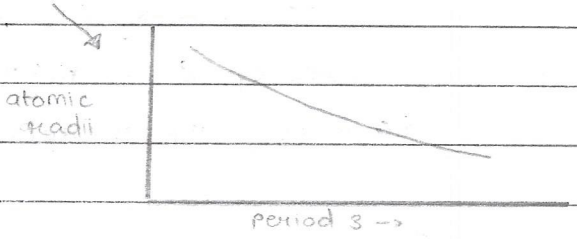
* No of e⁻ increases ∴ atomic size increases (new shells)
  ↳ nuclear charge increases
* Shielding effect increases ∴ force of attraction between last shell e⁻ and nucleus decreases.
  ↳ This outweighs increase in nuclear charge

so Atomic radii INCREASES.

Accross the period.

* e⁻ are added to same shell ∴ atomic size decreases.
  ↳ nuclear charge increases.
* shielding effect remains constant ∴ greater force of attraction between last shell e⁻ and nucleus.

so Atomic radii DECREASES.



Q-3) Patterns of ionic radii

Cations are positive ions

Anions are negative ions

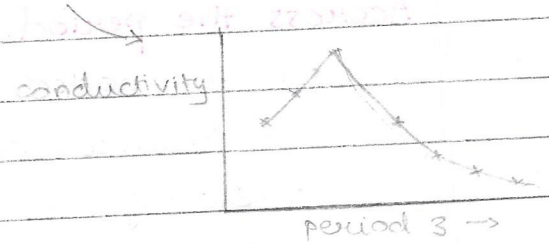
* Cations are smaller in size compared to their respective atom because they're formed by a loss of e⁻.
* Anions are larger in size compared to their respective atom because they're formed by a gain of e⁻

Q-4) Patterns in electrical conductivity

* Na, Mg, Al
  - ↳ giant metallic structure
    - ↳ free e^- are available ∴ they are good conductors.
  - ↳ From Na - Al, conductivity increases because no. of e^- it can donate increases (delocalised e^-).

* Si
  - ↳ giant covalent structure
    - ↳ no free e^- ∴ a semi-conductor

* P_4, S_8, Cl_2
  - ↳ simple molecular
    - ↳ no free e^- ∴ bad conductors / insulators



Q-5) Patterns in melting points.

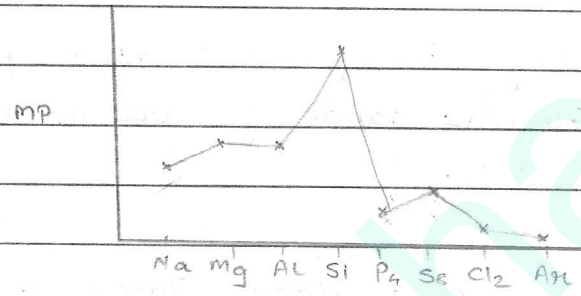
* Na, Mg, Al.
  - ↳ metalic bonding
    - ↳ strong forces of attraction between positive ions and sea of e^-. ∴ high energy required to break bonds.

Na -> Al, mp increases, as no. of delocalised e^- increase

* Si
  - ↳ giant covalent structure
    - ↳ strong covalent bonds ∴ more energy required to break bonds.

* P_4, S_8, Cl_2, Ar
  - ↳ simple molecular
    - ↳ weak VVF ∴ less energy required to break bonds.

* $S_8 > P_4$
  - ↳ Sulphur is a larger molecule than Phosphurus.
    ∴ greater surface area
    ∴ greater VWF
    ∴ more energy required to break bonds.



Q-5) Pattern in 1st ionisation energy

Down the group
* IE decreases
  - ↳ nuclear charge increases
  - ↳ shielding effect increases
  - ↳ atomic radii increases.

Accross the group
* IE increases
  - ↳ nuclear charge increases
  - ↳ shielding effect remains constant
  - ↳ atomic radii decreases.

Q-6) Reaction of period 3 elements with oxygen.

* Sodium reacts vigorously with oxygen, burns with a yellow flame and forms a white solid.

$$4Na_{(s)} + O_{2(g)} \longrightarrow 2Na_2O_{(s)}$$

* Magnesium reacts vigorously, burns with a white flame.

$$2Mg_{(s)} + O_{2(g)} \longrightarrow 2MgO_{(s)}$$

* Aluminium reacts vigorously, burns with a white flame

$$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$$

* Silicon reacts slowly with oxygen.

$$Si(s) + O_2(g) \rightarrow SiO_2(s)$$

* Phosphorus reacts vigorously, burns with a yellow flame and clouds of white phosphorus(V) oxide gas are produced.

$$4P(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$$

* Sulphur burns gently with a blue flame. Toxic fumes of sulfur dioxide are produced (gas).

$$S(s) + O_2(g) \rightarrow SO_2(g)$$

$$2SO_2(g) + O_2(g) \overset{V_2O_5 \text{ catalyst}}{\rightleftharpoons} 2SO_3(g)$$

* Chlorine and Argon don't react with oxygen.

↳** $4Cl(g) + 7O_2(g) \rightarrow 2Cl_2O_7(g)$

Q-7) Oxides of period 3.

> Reactions with water:

basic oxide

$$Na_2O + H_2O \rightarrow 2NaOH$$

$$MgO + H_2O \rightarrow Mg(OH)_2$$

acidic oxide

$$P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$$

$$SO_2 + H_2O \rightarrow H_2SO_3$$

$$SO_3 + H_2O \rightarrow H_2SO_4$$

Acids react with bases.

$$Al_2O_3 + 2H_2O + 3NaOH \rightarrow 2NaAl(OH)_4$$

$$Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$$

$$Al_2O_3 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2O$$

Bases react with acids.

$$SiO_2 + 2NaOH \rightarrow Na_2SiO_3 + H_2O$$

$$SO_3 + 2NaOH \rightarrow Na_2SO_4 + H_2O$$

$$Na_2O + 2HCl \rightarrow 2NaCl + H_2O$$

oxides	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_2 / SO_3	Cl_2O_7
oxidation no.	+1	+2	+3	+4	+5	+4 / +6	+7
Acid/Base nature	Basic	Basic	Amphoteric	Acidic	Acidic	Acidic	Acidic
Relative mp	High	v. high	v. high	v. high	low	low	low
Bonding	ionic	ionic	ionic with covalent character	← covalent →			
Structure	← Giant ionic →			Giant covalent	← Simple molecular →		
pH	13 - 14	11 - 12	-	-	2 - 4	2 - 4	-
Reaction with water	vigorously with cold H_2O.	slowly with cold H_2O vigorously with steam	← No reaction →		← vigorously with cold H_2O →		

Q-8) Reaction of period 3 elements with chlorine.

* Sodium metal, when heated, reacts vigorously with Chlorine.

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$$

↳ white product, orange flame

* magnesium reacts vigorously

$$Mg(s) + Cl_2(g) \rightarrow MgCl_2(s)$$

↳ white product, white flame

* Aluminium reacts vigorously

$$2Al(s) + 3Cl_2(g) \rightarrow Al_2Cl_6(s)$$

↳ ~~white~~ yellow product, yellow flame.

* Silicon reacts slowly

$$Si(s) + 2Cl_2(g) \rightarrow SiCl_4(\ell)$$

↳ colourless liquid.

* Phosphorus reacts slowly with excess Chlorine.

$2P(s) + 5Cl(g) \rightarrow 2PCl_5(l)$

↳ yellow flame ~~* clouds of white smoke~~

* $S + Cl_2 \rightarrow SCl_2$. — NOT in detail for AS.

↳ ~~blue flame * colourless~~ orange liquid

Q-9) Chlorides of period 3.

Chloride	NaCl	$MgCl_2$	Al_2Cl_6	$SiCl_4$	PCl_3 / PCl_5	SCl_2
oxidation no.	+1	+2	+3	+4	+3 / +5	+2
Bonding	← ionic →		Dimeric covalent	← covalent →		
Structure	← Giant ionic →		← Simple molecular →			
Observation when added to water	white solids dissolve to form colourless solution →		← Reacts with H_2O and gives out fumes of $HCl(g)$ →			
pH	7	6.5	3	2	2	2

* Reaction with water:

$NaCl(s) + aq \rightarrow Na^+(aq) + Cl^-(aq)$

$MgCl_2(s) + aq \rightarrow Mg^+(aq) + 2Cl^-(aq)$

$AlCl_3(s) + aq \rightarrow [Al(H_2O)_6]^{3+}(aq) + 3Cl^-(aq)$

$SiCl_4(l) + 2H_2O(l) \rightarrow SiO_2(s) + 4HCl(g)$

$PCl_5(l) + 4H_2O(l) \rightarrow H_3PO_4(aq) + 5HCl(g)$

Q-10) Reaction of Na and Mg with water.

> Na reach vigorously with cold water, melting into a ball of molten metal. it moves across the surface of water, giving off hydrogen gas.
It's v. soluble and leaves a strong alkaline solution (eg: pH 14)

$$2Na_{(s)} + 2H_2O_{(l)} \longrightarrow 2NaOH_{(aq)} + H_{2(g)}$$

> Mg reach slowly with cold water, taking several days to produce the test tube of $H_{2(g)}$.
it's slightly soluble ∴ leaves a weak alkaline solution (eg: pH 11) as few OH^- ions are released.

$$Mg_{(s)} + 2H_2O_{(l)} \longrightarrow Mg(OH)_{2(aq)} + H_{2(g)}$$

Mg reacts vigorously with steam.

$$Mg_{(s)} + H_2O_{(g)} \rightarrow MgO_{(s)} + H_{2(g)}$$