Trends in the Periodic Table

Question 1 (2015 - Section B - Question 11 - Part a)

QUESTION 11

(*a*) DEFINE: **relative (measure of force of, number expressing the) attraction** that an atom has // **for shared pair** of electrons / for **electrons in a covalent bond** (2 × 3)

WHY: **nuclear charge (number of protons, atomic number, number** of **positive** particles in **nucleus) increasing** //
atomic radius decreasing (2 × 3)

EXPLAIN: predicted the properties from properties of **known elements** / predicted the properties from properties of **elements** in **same group (column, family)** (6)

or

having **arranged (placed) elements in order of increasing atomic weight (mass)** / where **elements with similar properties were arranged in columns (groups, families)** / **left gaps** in his table for elements with certain properties yet to be discovered (3 only)

WRITE: **GeH_4** (3)

WOULD: **no** //
GeH_4 a **non-polar (slightly polar)** solute / **insoluble in water** like **methane (CH_4, silane, SiH_4)** **(2 × 2)**
[Second (2) only available if first (2) is awarded.]

Question 2 (2015 - Section B - Question 4 - Part h)

(*h*) IDENTIFY: (*i*) **sodium (Na)** //
(*ii*) **beryllium (Be)** (2 × 3)

Question 3 (2014 - Section B - Question 5 - Part (b) - (c))

(*b*) DEFINE: the minimum **energy required to remove the most loosely-bound (outermost) electron // from an isolated (gaseous) atom in its ground state / from one mole of isolated (gaseous) atoms in their ground state** (2 × 3)

EXPLAIN: (*i*) **greater nuclear charge / greater number protons in nucleus // smaller atomic radius** (2 × 3)
['Greater atomic number' not acceptable.]

(*ii*) **greater atomic radius / most loosely-bound (outermost) electron farther from nucleus / most loosely-bound (outermost) electron more shielded from nucleus** (3)
['More shells' acceptable.]

(*c*) EXPLAIN: there are **three groups of ionisations (electrons, points) with gradual (small) energy differences** between them because they involve **electrons in the same** energy **level (shell) //**

there are **two bigger energy differences (jumps) between these groups of ionisations (electrons, points)** because the three **energy levels have significantly different** discrete (fixed, restricted, definite, specific) **energies** (2 × 3)

or

sharp (bigger) increase (jump) in ionisation energy **for 5th (from 4th to 5th) electron** showing that this is the first electron to be **removed from 2nd (*n* = 2, new, full, next, another)** main **level (shell) //**

sharp (bigger) increase (jump) in ionisation energy **for 13th (from 12th to 13th) electron** showing that this is the first electron to be **removed from 1st (*n* = 1, new, full, next, another)** main **level (shell) //**

gradual (small) increase for first four electrons, therefore **in same** main **level (shell) / gradual (small) increase from 5th to 12th** electrons, therefore **in same** main **level (shell) / gradual (small) increase from 13th to 14th** electrons, therefore **in same** main **level (shell)**
ANY TWO: (2 × 3)

[Responses here must make sense and not just contain the correct phrases – beware of *incorrect* use of sublevel and orbital.]

OTHER: **line** emission (absorption) **spectra** of elements (3)

Question 4 (2013 - Section B - Question 11 - Part (a))

QUESTION 11: Answer any *two* of the parts *(a)*, *(b)* and *(c)*.

(a) DEFINE: minimum energy to **remove most loosely-bound (highest energy, outermost) electron //**

from an **isolated (gaseous) atom in its ground (lowest energy) state /** from **1 mole of isolated (gaseous) atoms in their ground (lowest energy) state** (4 + 3)

(i) DEDUCE: *B* is **helium //** *P* is **sulfur (sulphur)** (2 × 3)

WHAT: **900** (3)

(ii) WHAT: **R** (argon) **has (by losing an electron S** (potassium) **gets) stable** outer **octet** of electrons **{noble gas configuration, full outer sublevel (subshell), outer $3p^6$} / S has outer electron further from nucleus {in a new** main **level (shell), / S more screened} / S's electron removed from next (4^{th})** main **level (shell) / S has one electron in outer** main **level (shell)** (3)
["R has full outer shell" (0 marks) but doesn't cancel a correct point]

(iii) EXPLAIN: a **half-full** *p* **sublevel has** associated **stability** / **paired electrons in a** *p* **orbital unstable //**

H (oxygen) has lower first ionisation energy (loses electron more easily) because it has a **less stable electron configuration** than G / is **one electron above (away from) stability / $2p_x^2 2p_y^1 2p_z^1$ or $2p^4$ or $2p$** ↑↓ | ↓ | ↓ **/ loss of electron from H gives half-full $2p$**

G (nitrogen) has higher first ionisation energy (loses electron less easily) because it has a **more stable electron configuration** than H / **$2p_x^1 2p_y^1 2p_z^1$** or **$2p^3$ or $2p$** ↓ | ↓ | ↓ / **half-full $2p$**-sublevel /

(2 × 3)

Question 5 (2012 - Section B - Question 5 - Part (b) - (e))

(b) DEFINE: **half internuclear distance (half distance between the centres** of the atoms**) in a single homonuclear bond (of singly-bonded atoms of the** same **element)** (6)

STATE: **decrease** in atomic radius (3)

EXPLAIN: **increase in** effective **nuclear charge (number of protons)** (3)

(c) REASON: **increase in nuclear charge (number of protons) / decrease in atomic radius** (3)

(d) *(i)* STATE: **PH_3** virtually **non-polar** (pure **covalent**) but the **other three** are **polar** covalent (3)

WHAT: **tiny (no) electronegativity difference in PH_3 (between P and H)** but much **bigger electronegativity differences in the other three.** (3)

(ii) FROM: **H_2O // NH_3** (2 × 3)
[Award 6 marks if H_2O, NH_3 and HCl offered]

GIVE: **melting point / boiling point / surface tension / capillarity / specific heat / latent heat of fusion / latent heat of vaporisation / density / solubility in water** (3)

(iii) SHAPE: **pyramidal** (3)

EXPL: repulsion between **four electron pairs (e.p.), one a lone pair (l.p.) /**

repulsion between **three bonds (bond pairs, b.p.) and a (one) lone pair (l.p.)** (3)

(e) WOULD: *(i)* B – Cl bond: **polar** // *(ii)* BCl_3 molecule: **non-polar** (2 × 3)

JUSTIFY: **unequal sharing of electrons (el. neg. difference)** between B and Cl **(polarity of bonds) cancels due to symmetry of molecule(s) /**
centres of positive and negative charge coincide (3)

Question 6 (2005 - Section B - Question 10 - Part (b))

(b) (i) IDENTIFY: **first ionisation energy / first ionisation potential** (4)
[Allow 3 marks for ionisation energy (potential)]

STATE: **kilojoules per mole (kJ mol^{-1}) / joules per mole (J mol^{-1}) / electron volt(s) (eV)** (3)

(ii) EQUATION: $X_{(g)} \longrightarrow X^+_{(g)} + e^-$ / $X_{(g)} - e^- \longrightarrow X^+_{(g)}$ (6)
[Allow (3) for equation given without state symbols]

(iii) WOULD: **less** (3)

EXPLAIN: **already gained energy (partially removed) / already raised to higher level /** already **excited /further from nucleus** (3)
[The (3) for EXPLAIN cannot be awarded if the answer to WOULD is incorrect]

(iv) HOW: **very / quite / fairly / reactive** (3)

REACT: by **losing electron(s) / oxidised / becoming positively charged** (3)