Mark Scheme - PI2.1 Chemistry of the p-block

1 nitrogen / phosphorus (or any other Group 5 element) **[1]**

[1]

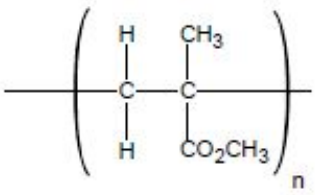
2 

3 (a) (i) one σ bond/ description of σ bond/ diagram to show overlap of s orbitals (1)

one π bond/ description of π bond/ diagram to show sideways overlap of p orbitals (1)

[2]

(ii) joining of **many/lots of** (small) units or many alkenes / molecules to make a **large/long** unit/ molecule [1]

(iii) 

[1]

(iv) C_4H_5Cl [1]

(b) (i) BF_3 is planar triangular/ trigonal planar (1)

NH_3 is pyramidal/ trigonal pyramid (1) [2]

(ii) BF_3 has 3 bond pairs (1)

NH_3 has 3 bond pairs and 1 lone pair (1) [2]

QWC the information is organised clearly and coherently, using specialist vocabulary where appropriate [1]

(c) (i) co-ordinate/ dative covalent/ dative
- no credit for 'covalent' [1]

(ii) 109½° (accept any in range 109°-110°) [1]

(iii) 4 bond pairs/ bonds (around B)
- no credit for 'tetrahedral' [1]

Total [13]

4 (a) +1 occurs due to inert pair of s-electrons (1)
Inert pair effect becomes more significant down the group (1) [2]

(b) (i)

B	H
78.14	21.86
10.8	1.01
7.235	21.644
1	3

(1)

Empirical formula = BH_3 (1) [2]

(ii) Number of moles = $1/22.4 = 4.46 \times 10^{-2}$ moles (1)

$M_r = 1.232 / 4.46 \times 10^{-2} = 27.6$ (1)

Molecular formula = B_2H_6 (1) [3]

(c) Outer/valence shell of electrons is not full / does not have an octet [1]

(d) $B_5H_9 + 15H_2O \rightarrow 5H_3BO_3 + 12H_2$ [1]

(e) The compound is less stable than the elements [1]

(f) Any 3 from 4 points for (1) each

All atoms the same in graphite / BN alternate in boron nitride (1)
Atoms in layer of BN lie above each other but are not in graphite (1)
B—N bonds are polarised (or indicated dipole) but graphite is non-polar (1)
p-electrons in BN are localised but in graphite are delocalised (1) [3]

QWC *Organisation of information clearly and coherently; use of specialist vocabulary where appropriate* [1]

(g) Mass number = 7 Atomic number =3 [1]

Total [15]

5 (a) (i) Oxidising agent [1]

(ii) A = lead(II) chloride / $PbCl_2$ (1)

B = chlorine / Cl_2 (1) [2]

(iii) $[Pb(OH)_6]^{4-}$ / $[Pb(OH)_4]^{2-}$ / $Na_4[Pb(OH)_6]$ etc. [1]

(iv) Yellow [1]

(v) $PbO + 2HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O$ [1]

(b) (i) Each C atom covalently bonded to three other C atoms forming layers (1)

Layers held together by weak intermolecular forces (1)

BN is isoelectronic with C so it forms similar structures (1)

Graphite conducts electricity since electrons are delocalised but in BN, each N has a full unbonded p-orbital and each B has an empty unbonded p-orbital so it does not conduct electricity (1) [4]

(Accept electrons are not delocalised in BN so it does not conduct electricity)

QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate [1]

(ii) Wear-resistant coatings/catalyst support/for mounting high power electronic components / drills in industry / cutting instruments [1]

(c) (i) $\Delta G = \Delta H - T\,\Delta S$ ($\Delta G = 0$ for reaction to be spontaneous) (1)

$T = \frac{1.92}{0.0067}$ (1)

$T = 286.6$ K (1) [3]

(ii) Changes in temperature (above or below 286.6 K) caused the tin to change form making it unstable (and causing it to disintegrate) [1]

(d) (i) (At the anode) $H_2 \longrightarrow 2H^+ + 2e^-$ (1)

(At the cathode) $O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$ (1)

(Overall reaction) $2H_2 + O_2 \longrightarrow 2H_2O$ (1)

[3]

(ii) Hydrogen is difficult to store / takes up large volume / too flammable / explosive / produced from fossil fuels which leads to a net energy loss / Pt electrodes very expensive [1]

Total [20]

6 (a) Electrons within atoms occupy fixed energy levels or shells of increasing energy / nitrogen has electrons in two shells (1)
$1s^2 2s^2 2p^3$ (1)

Electrons occupy atomic orbitals within these shells /
The first shell in nitrogen has s orbitals and the second shell s and p orbitals (1)

A maximum of two electrons can occupy any orbital /
Each s orbital in nitrogen contains two electrons (1)

Each with opposite spins (1)

Orbitals of the same type are grouped together as a sub-shell / There are three p orbitals in nitrogen's p sub-shell (1)

Each orbital in a sub-shell will fill with one electron before pairing starts / In nitrogen's p sub-shell each orbital contains one electron (1)

(configuration mark + any 3 of above) [4]

QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate [1]

(b) Atomic spectrum of hydrogen is a series of lines (1)
that get closer as their frequency increases (1)
(credit possible from labelled diagram)

Lines arise from atom / electrons being excited by absorbing energy (1)
electron jumping up to a higher energy level (1)
falling back down and emitting energy (in the form of electromagnetic radiation) (1)
to the n = 2 level (1)
(any **three** points for maximum 3 marks)

Since lines are discrete energy levels must have fixed values / Since energy emitted is equal to the difference between two energy levels, ΔE is a fixed quantity or quantum (1)

[6]

(c) (i) It has greater nuclear charge (1)
but little / no extra shielding (1) [2]

(ii) In Be less shielding of outer electron (1)
outweighs smaller nuclear charge (1)

or

Be outer electron closer to nucleus (1)
Be has greater effective nuclear charge (1) [2]

(iii) I. Too much energy required to form B^{5+} ion [1]

II. $K^+(g) \rightarrow K^{2+}(g) + e^-$ [1]

III. Value of 1st and 3rd I.E. will be higher (1)
Value of 2nd I.E. will be smaller (1)
(accept large jump in I.E. value would be between 2nd and 3rd electrons for 1 mark) [2]

Total [19]

7 (a)

- BCl_3 is trigonal planar or clear diagram.
- NCl_3 is pyramidal or clear diagram.
- BCl_3 has 3 bonded pairs
- NCl_3 has 3 bonded pairs
- NCl_3 has a lone pair
- BCl_3 has no lone pair
- Electron pairs repel to be as far from each other as possible / position of minimum repulsion.
- Lone pairs repel more than bonded pairs.

First two points and any other 4 for (1) each up to 6 max [6]

- *QWC: selection of a form and style of writing appropriate to purpose and to complexity of subject matter.[1]*
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- *QWC: legibility of text, accuracy of spelling, punctuation and grammar, clarity of meaning.[1]* [2]

(b)

accept crosses and dots exchanged (1)

Electron deficient: outer shell of boron has less than 8 electrons / is not full.(1) [2]

(c) NH_3 can form hydrogen bonds with water molecules (so it dissolves) (1)
NCl_3 cannot form hydrogen bonding. (1) [2]

(d)

- Covalent has a pair of shared electrons one from each atom (1)
- Coordinate has a pair of shared electrons both electrons from same atom (1)

[2]

Total [14]