Chemical Bonding

Question 1 (2015 - Section B - Question 4 - Part d)

(*d*) ACCOUNT: **boron** [central atom of **boron trifluoride (BF_3)] has three bond pairs** of electrons //
nitrogen [central atom of **ammonia (NH_3)] has three bond pairs and one lone pair** of electrons

or

boron [central atom of **boron trifluoride (BF_3)] has three** valence **pairs of electrons** //
nitrogen [central atom of **ammonia (NH_3)] has four** valence **pairs of electrons**

or

both ammonia and boron trifluoride **have three bond pairs** of electrons //
but **ammonia (NH_3)** also **has one lone pair**

(2 × 3)

[*Marks available for good diagrams.*]

Question 2 (2014 - Section B - Question 11 - Part (a))

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

ACCOUNT: **lone pair** of electrons **has greater repelling power than** a **bond pair** of electrons **//**
bonds (H atoms) in NH_3 pushed closer together than in SiH_4 **/**
ammonia has three bond pairs (one lone pair) where **silane has four bond pairs (no lone pair)** (2 × 3)

USE: electronegativity differences: **N – H = 0.84; Si – H = 0.3 => N – H** more polar **/**
electronegativity difference greater for N – H => N – H more polar (3)

WHICH: **ammonia //** (3)

JUSTIFY: in ammonia **hydrogen bonded to a small, highly (very) electronegative element (atom) /**
when hydrogen bonding occurs **hydrogen bonded to nitrogen, oxygen or fluorine** (3)
[Both parts to be linked].

GIVE: **centres of** positive and negative **charge coincide** / **dipole** moments **cancel / symmetrical (even) distribution (arrangement) of bonds in 3d(imensional space) around central atom** **(4)**
[Examples insufficient; reference to 'symmetry' **un**acceptable unless in sufficient detail; 'charges cancel' is **not** acceptable.]

Question 3 (2014 - Section B - Question 4 - Part (e))

(*e*) HOW: (*i*) **1** sigma **//** (*ii*) **2** pi (2 × 3)

Question 4 (2013 - Section B - Question 10 - Part (a))

(a) DISTINGUISH: *intramolecular*: forces between atoms **in (within, inside) molecules** //
intermolecular: forces **between molecules** (4 + 3)
[Marks may be awarded for diagrams that clearly show the necessary information.]

(i) **hydrogen smaller {has fewer (two) electrons}** *[Accept "lighter".]* / therefore **weaker (less) intermolecular (van der Waals, dispersion, London, dipole-dipole) forces (attractions, interactions)** (6)
[N.B. Answer could be given in terms of oxygen (N.B. 16 electrons).]

(ii) iodine pure **covalent (non-polar)** //
water a **polar** solvent / **intermolecular (van der Waals, etc.) forces (attractions, interactions)** between iodine and water very **weak** (2 × 3)

(iii) charge on rod **attracts** // opposite charge on **polar (dipole of)** water molecule (2 × 3)

Question 5 (2013 - Section B - Question 4 - Part (d))

(d) GIVE: **tetrahedral** // **109° 28'** *[Accept 109 – 109.5°]* (2 × 3)
[Accept good diagram]

Question 6 (2012 - Section B - Question 4 - Part (d))

(d) DISTING: *sigma*: **head-on (end-on) overlap of orbitals** //
pi: **lateral (sideways) overlap of p-orbitals** (2 × 3)
[Marks can be got from clear diagrams. Allow only 3 if "orbitals" omitted from statements or not labelled in diagrams.]

Question 7 (2011 - Section B - Question 11 - Part (b))

(b) (i) DIST: *ionic*: bond (force of attraction) **between oppositely-charged ions /**
bond involving transfer (loss and gain) of electrons //

polar: **unequal sharing of** bonding **electrons {electron pair(s)} /**
bond has **slight positive (δ^+) and slight negative (δ^-)** ends (4 + 3)

(ii) WHY: *molten/dissolved*: **ions free to move //**
solid: **ions not free to move / ions locked (fixed)** in position (2 × 3)

(iii) SHOW: there is an **electronegativity difference (values acceptable)** between N and H //
showing **unequal sharing / N with greater attraction / H with smaller attraction / $N^{\delta-} - H^{\delta+}$** (2 × 3)

DESC: **hydrogen bonds between slightly neg O ($O^{\delta-}$) of water and H** of ammonia //
and **between slightly pos H ($H^{\delta+}$) of water and N** of ammonia (2 × 3)

or

breaking of hydrogen bonds in water //
forming of hydrogen bonds between ammonia and water (2 × 3)

Question 8 (2010 - Section B - Question 10 - Part (a))

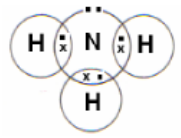
STATE: **H_2O // NH_3** (2 × 3)

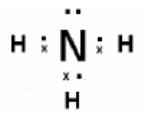
JUSTIFY: **Hydrogen bonded to small highly electronegative element (bonded to O, N, F)**
[If either one of "small / highly" omitted (– 1)] (3)

SUGGEST: **Weaker (less effective)** hydrogen bonding in ammonia **/ stronger (more effective)** hydrogen bonding **in water / smaller electronegativity difference for NH bond / bigger electronegativity difference for OH bond / electronegativity lower for N** than O **/ electronegativity higher for O** than N / **NH bond less polar / OH bond more polar / ratio of lone pairs to H atoms in water is 1:1** (4)

Question 9 (2009 - Section B - Question 11 - Part (b))

(b) (i) USE: (7)





[Correct shape not reqd. Accept all dots or all crosses. For bonds accept x—•]

(ii) EPRT: **three bonding** and **one non-bonding (lone) pair** / **four electron (valence) pairs*** // giving bond arrangement (shape of molecule) to be **pyramidal**** *[** 'distorted tetrahedron' not acceptable for 'pyramidal' but does not cancel]* (2 × 3)

[Tripod-like diagram acceptable for second (3). Allow even if lone pair is shown.]

*[**Allow this (3) from correct diagram in (i) provided "lone pair" is mentioned in (ii)]*

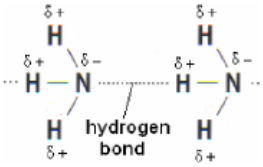
EXPLAIN: **greater repelling power (repulsion) of lone pair / lone pair pushes bonds closer** together [Allow "l.p.: b.p. > b.p.: b.p." or "l.p.: l.p. > l.p.: b.p. > b.p.: b.p."] (3)

(iii) WHAT: **intermolecular (between molecules)** attraction *[Can be got from diagram below or other suitable diagram.]* (3)

involving slightly (δ) **positive (+) hydrogen (H)** atom and slightly (δ) **negative (–) atom {highly electronegative element(s)/atom(s), F, O, N}**

[Charges can be got from diagram below or other suitable diagram.] (3)

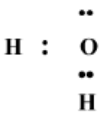
DRAW: (3)

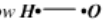
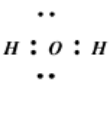


[One hydrogen bond must be shown with δ neg. charge on the N and δ pos charge on the H. If unlabelled, it may be assumed that the dotted line (or line that is different from the other bonds e.g. in colour) is meant to be a hydrogen bond. Both molecules must be ammonia.]

Question 10 (2003 - Section B - Question 5 - Part (b) - (c))

(b) Electronegativity: **relative (measure of) attraction / number expressing (giving) attraction** (3)
for shared electrons / for electrons in a covalent bond (3)

(i)  (9)

Allow  *for*  *Also allow* 

(Correct shell diagrams perfectly acceptable. All dots acceptable for dots and crosses)

(ii) Shape: **v-shaped / bent** (3)

Angle: **104°** (3)

Explain: **greater repulsion by lone pairs / l.p.– l.p. > etc.** (3)

pushes bonds closer together / reduces (lowers) bond angle (3)

(c) Observe: **water attracted to rod** (6) *Allow (3) for "deflected"*

Explain: **water is polar** (3)

Allow "water has (is) a dipole" or correct dipole diagram (non-linear with charges)