Topic 4: Bonding / 2020 Review

Key

1a. [2 marks] This question is about compounds of sodium.

Describe the structure and bonding in solid sodium oxide.

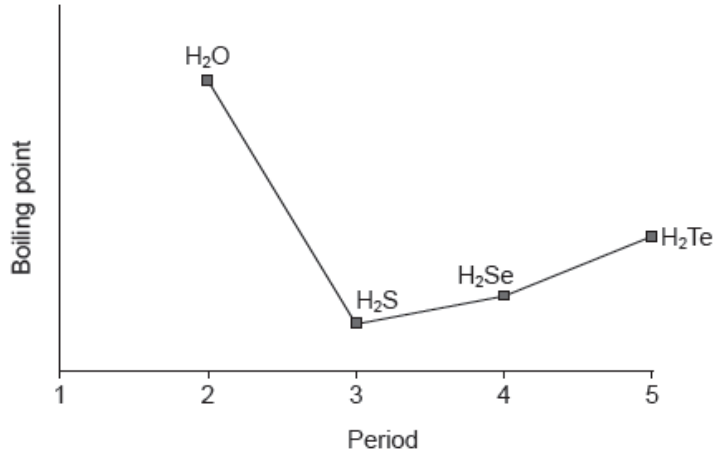
Regularly repeating arrangement of oppositely charged ions within a crystal lattice. Specifically, the attraction between two sodium ions (Na^+) for every one oxide ion (O^{2-}).

2a. [2 marks] Some physical properties of molecular substances result from the different types of forces between their molecules.

Explain why the hydrides of group 16 elements (H_2O, H_2S, H_2Se and H_2Te) are polar molecules.

These hydrides all have a bent shape due to the two lone pair of electrons on the central atom. This makes the molecules polar and due to an uneven charge distribution.

2b. [2 marks] The graph shows the boiling points of the hydrides of group 16 elements.



Explain the increase in the boiling point from H_2S to H_2Te.

The number of electrons increases, which increases the London dispersion between the molecules.

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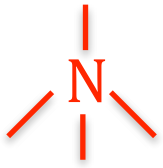
2c. [2 marks] Deduce the electron domain geometry and the molecular geometry for the NH_2^- ion.

electron domain geometry



tetrahedral

molecular geometry

bent

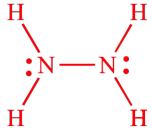
3a. [2 marks] Bonds can be formed in many ways.

The landing module for the Apollo mission used rocket fuel made from a mixture of hydrazine, N_2H_4, and dinitrogen tetraoxide, N_2O_4.

$N_2H_4(l) + N_2O_4(l) \rightarrow 3N_2(g) + 4H_2O(g)$

State and explain the difference in bond strength between the nitrogen atoms in a hydrazine and nitrogen molecule.

In the nitrogen molecule, the nitrogen atoms have a triple bond between its atoms (:N≡N:) and is much stronger than the single bond between the nitrogen atoms in hydrazine,

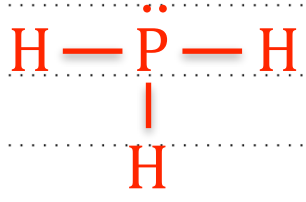


3b. [1 mark] State why hydrazine has a higher boiling point than dinitrogen tetraoxide.

Hydrazine has hydrogen bonding between its molecule which is a much stronger in intermolecular force than the dipole-dipole forces between dinitrogen tetroxide molecules.

4a. [4 marks] Phosphine (IUPAC name phosphane) is a hydride of phosphorus, with the formula PH_3.

(i) Draw a Lewis (electron dot) structure of phosphine.



(ii) Outline whether you expect the bonds in phosphine to be polar or non-polar, giving a brief reason.

Nonpolar. Hydrogen and phosphorous have the same electronegativity.

[see table 8 of the IB data booklet]

(iii) Explain why the phosphine molecule is not planar.

The lone pair of electrons repels the bonding electrons and forms a

pyramidal shape for the molecule.

(iv) Phosphine has a much greater molar mass than ammonia. Explain why phosphine has a significantly lower boiling point than ammonia.

Ammonia forms hydrogen bonds between it's molecules which are much

stronger than the dipole-dipole forces between phosphine molecules.

4b. [3 marks]

Phosphine is usually prepared by heating white phosphorus, one of the allotropes of phosphorus, with concentrated aqueous sodium hydroxide. The equation for the reaction is:

$P4\ (s) + 3OH^-\ (aq) + 3H_2O\ (l) \rightarrow PH_3\ (g) + 3H_2PO_2^-\ (aq)$

(i) Identify one other element that has allotropes and list two of its allotropes.

Element: Carbon

Allotrope 1: Any two:

Allotrope 2: diamond, graphite, graphene

C_{60} (buckminsterfullerene)

(ii) The first reagent is written as P_4, not 4P. Describe the difference between P_4 and 4P.

P_4 indicates that four phosphorus atom are covalently bonded together; it is a molecule. Whereas, 4P means four, nonbonded phosphorus atoms.

5d. [2 marks] Methanol (CH_3OH) has a lower molar mass than chloromethane (CH_3Cl). Explain why the boiling point of methanol is higher than that of chloromethane.

Methanol forms hydrogen bonds between it's molecules which are much stronger than the dipole-dipole forces between chloromethane molecules.

5f. [1 mark] Outline the nature of the metallic bonding present in potassium.

The electrostatic attraction between lattice of potassium cations and delocalized electrons.

5g. [2 marks] Describe the covalent bond present in the chlorine molecule and how it is formed.

The electrostatic attraction between positively charged nuclei and a pair of electrons; formed as a result of electron sharing.

6g. [1 mark] A chloride of titanium, $TiCl_4$, melts at* 248 K. Suggest why the melting point is so much lower than that of KCl.

$TiCl_4$ is molecular (1.7 difference in electronegativity between Ti and Cl), which makes the intermolecular forces between its molecules much weaker than the strong ionic bonding found in KCl.

* much lower than room temperature (≈295K) which is a big hint that it can't be an ionic compound.