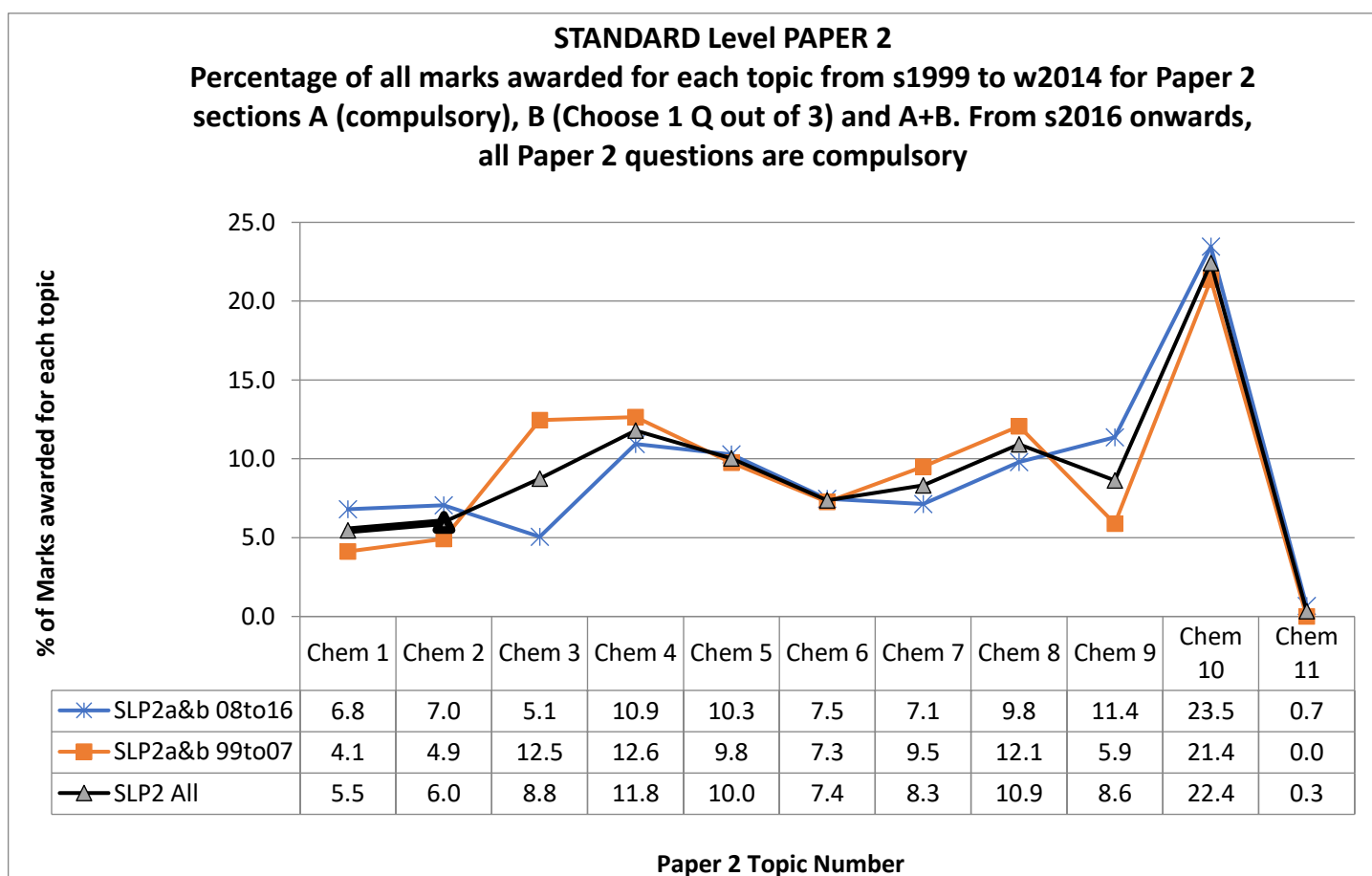
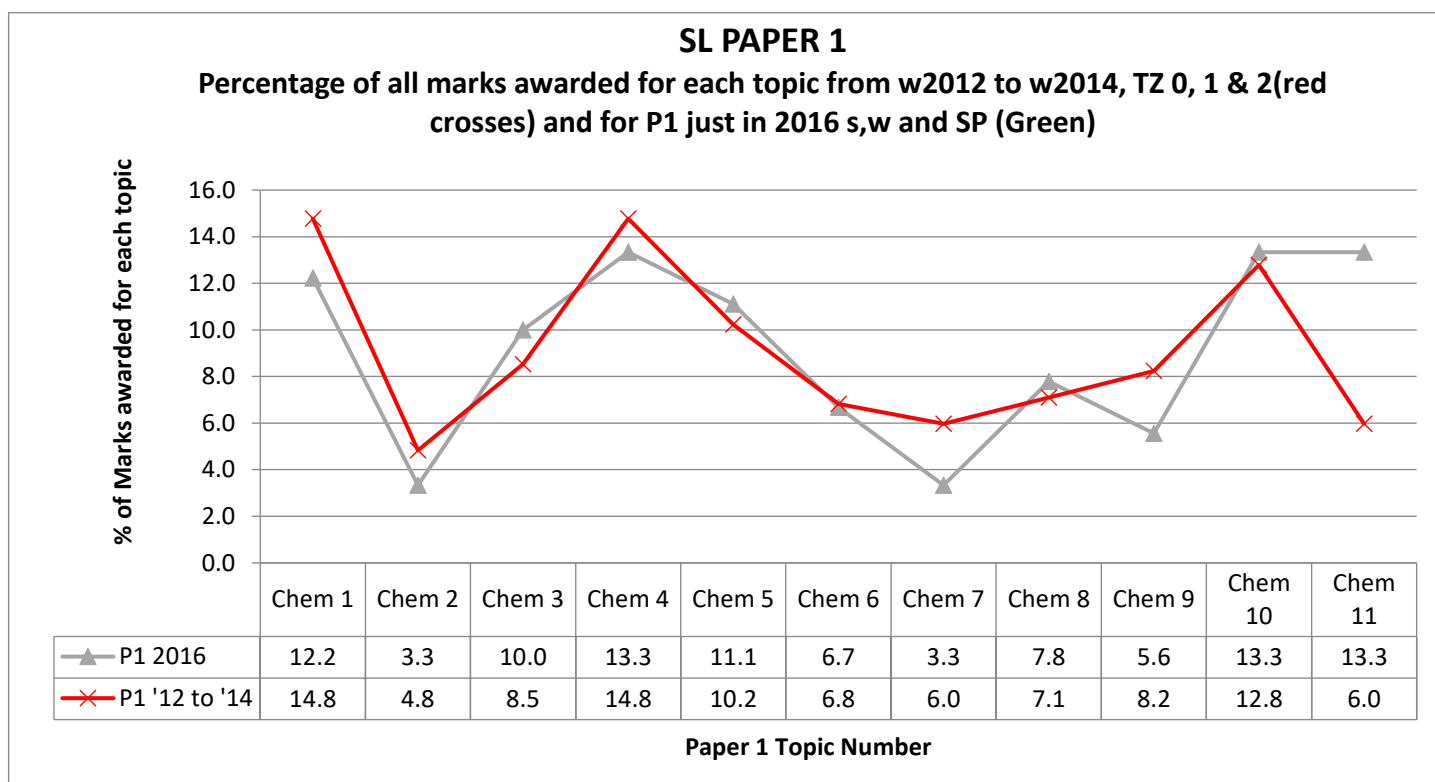


## IB 4 SL EQ P2 16w to 99s 325marks

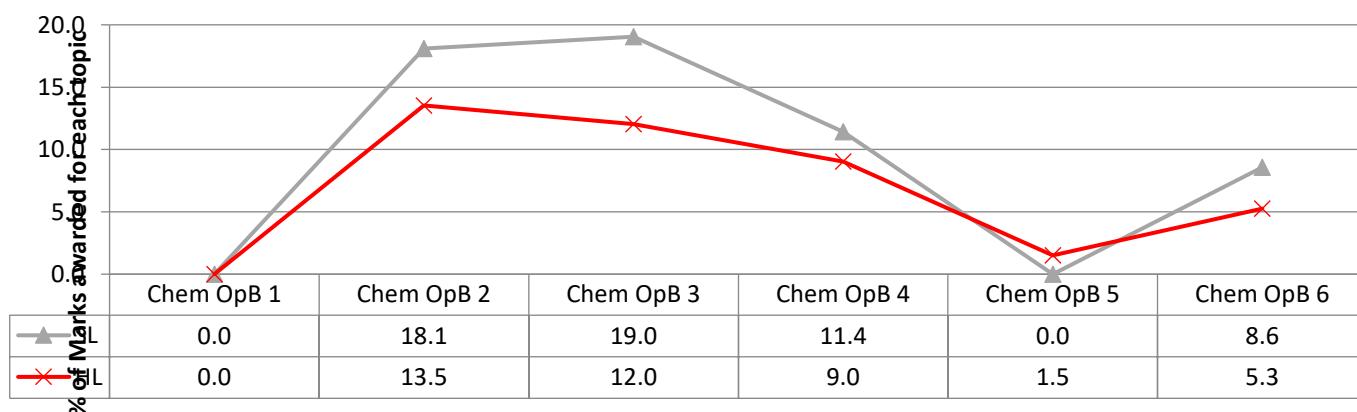
Before 2016 paper 2 was included 4 section B questions, of which you had to chose 2. After 2016 all questions became compulsory on Paper 2



All topics ranked according to their impact on your final grade using exam papers from 1999 to 2016

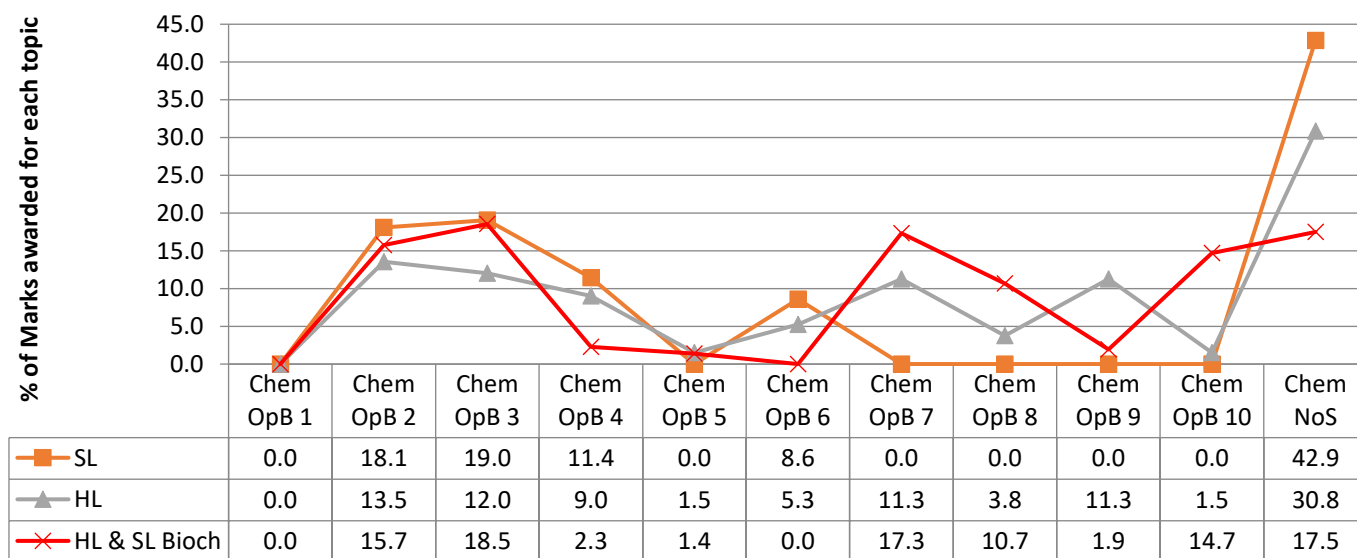
	TOPICS and IA													
	IA	10	Option	N.ofSci	4	5	8	3	1	9	7	6	2	11
Paper 1		12.8			14.8	10.2	7.1	8.5	14.8	8.2	6.0	6.8	4.8	6.0
Paper 2 16 to 08		23.5			10.9	10.3	9.8	5.1	6.8	11.4	7.1	7.5	7.0	0.7
Paper 2 07 to 99		21.4			12.6	9.8	12.1	12.5	4.1	5.9	9.5	7.3	4.9	0.0
Paper 2 ALL		22.4			11.8	10.0	10.9	8.8	5.5	8.6	8.3	7.4	6.0	0.3
Paper 3		0.0	57.1	42.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total % All Marks, Weighted	20	11.5	11.4	8.6	7.7	6.1	5.8	5.2	5.1	5.1	4.5	4.3	3.4	1.3
Rank Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14

### Human Biochem Mapped to SL Biochemistry for 2016



Biochemistry (2016) Topic Number - X = no longer examined

### IB SL & HL Human Biochem Option Mapped to Biochemistry Option for 2016



Biochemistry (2016) Topic Number - X = no longer examined

Essentially, Nature of Science (NoS) is almost half of the paper, sections after 6, so 7, 8 9 & 10 are only found in HL.

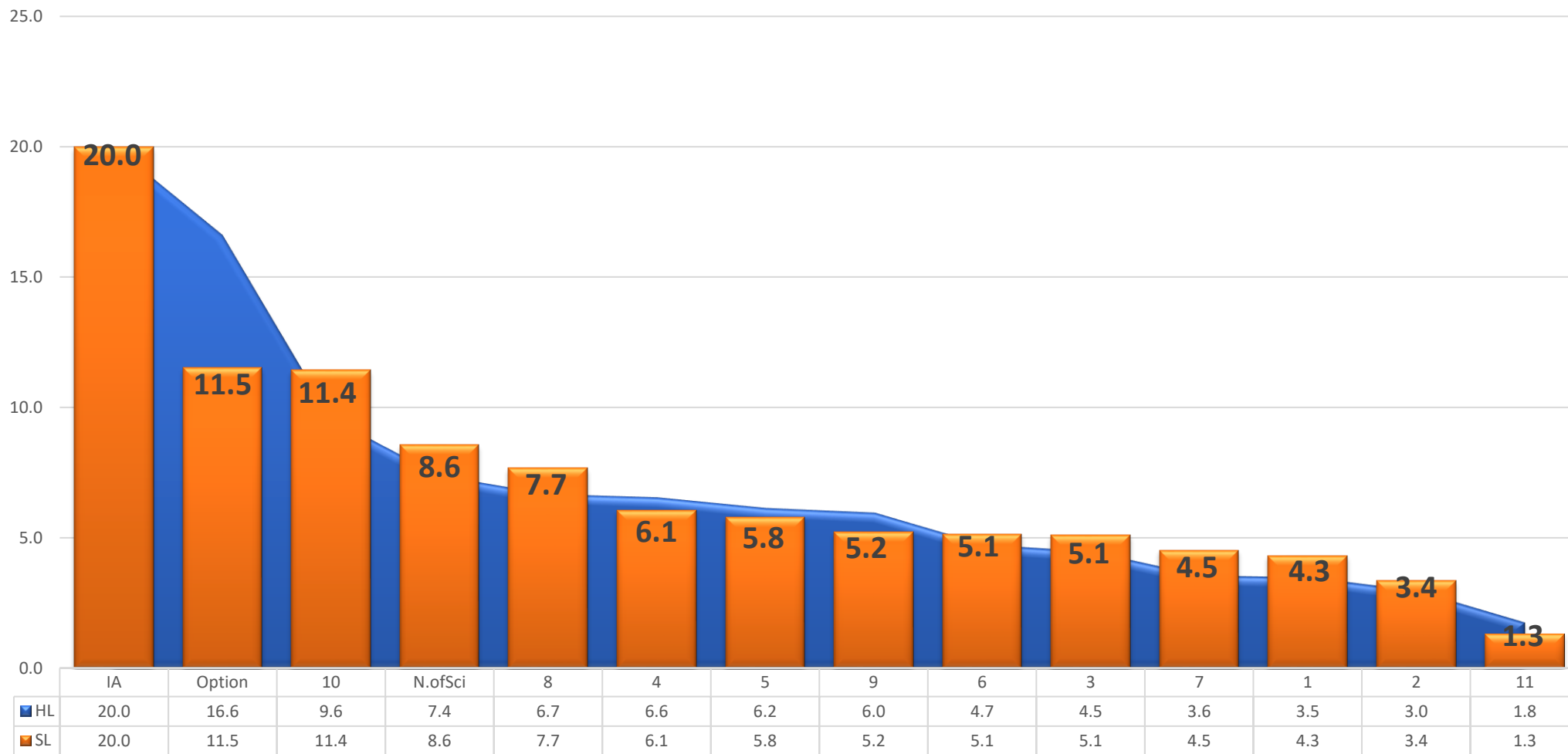
This is older data and will be updated in late 2019 (I stopped teaching IB in 2016, teaching A levels instead and started again in the second half of 2019).



## Standard and Higher Level components compared

**All topics Covered in SL RED columns and HL BLUE area in IB Chemistry in papers 1, 2 and 3 and IA**

**Percentage of all WEIGHTED marks awarded for each topic from exam papers from 1999 through to winter 2016.**



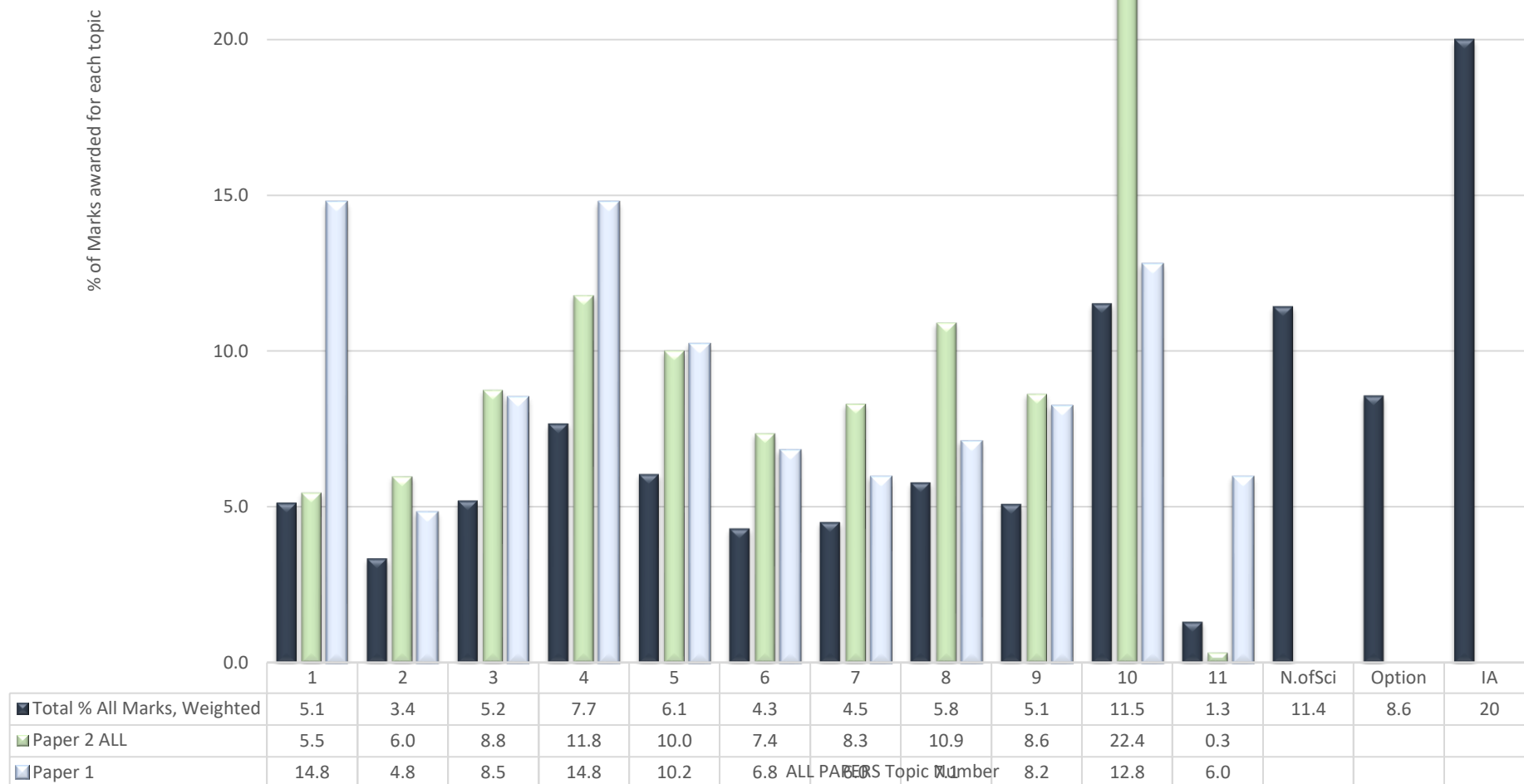
Essentially, IA has the exact same weight, the Option in HL is almost 50% more important than in SL but Topic 10 is more important in SL than HL. All other topics contribute almost equally to a SL and HL grade.



## All topics Covered in IB STANDARD Level Chemistry in papers 1, 2 and 3

### Percentage of all WEIGHTED marks awarded for each topic from exam papers from 1999 through to winter 2016.

% of Marks awarded for each topic



**The dark blue bars are where your final IB grade will be from:**

1. Your IA is the single most important part of your IB SL, more important than even the Option. Imagine how much time in class, at home and in revision you have or will give to topics 9, 10 and 11. **Your IA, on average, will be worth more to your final grade than all those combined.**
2. The Option is the most important topic for your IB grade compared to the everything else
3. Topic 10, Organic Chemistry, is by far the most important topic for papers 1 and 2.



Name

Q#. 1 IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q4

(f) Describe the structure and bonding in solid magnesium oxide.

[2]

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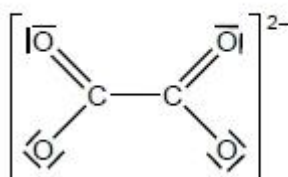
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Q#. 2 IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q2

2. The concentration of a solution of a weak acid, such as ethanedioic acid, can be determined by titration with a standard solution of sodium hydroxide, NaOH(aq).

(d) The Lewis (electron dot) structure of the ethanedioate ion is shown below.



Outline why all the C–O bond lengths in the ethanedioate ion are the same length and suggest a value for them. Use section 10 of the data booklet.

[2]

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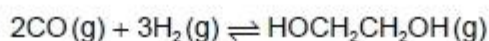
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Q#. 3 IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q1

1. Ethane-1,2-diol, HOCH<sub>2</sub>CH<sub>2</sub>OH, has a wide variety of uses including the removal of ice from aircraft and heat transfer in a solar cell.

(a) Ethane-1,2-diol can be formed according to the following reaction.



Ethene has the structural formula of CH<sub>2</sub>CH<sub>2</sub>

(c) Explain why the boiling point of ethane-1,2-diol is significantly greater than that of ethene.

[2]

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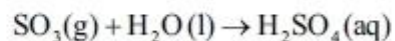
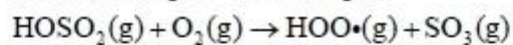
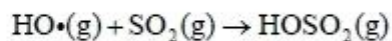
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2. One of the main constituents of acid deposition is sulfuric acid,  $\text{H}_2\text{SO}_4$ . This acid is formed from the sulfur dioxide pollutant,  $\text{SO}_2$ .

A mechanism proposed for its formation is:



(a)

- (ii) Draw one valid Lewis (electron dot) structure for each molecule below.

[2]

Molecule	Lewis (electron dot) structure
$\text{SO}_2$	
$\text{H}_2\text{O}$	

- (iii) Deduce the name of the electron domain geometry and the molecular geometry for each molecule.

[2]

	Electron domain geometry	Molecular geometry
$\text{SO}_2$	.....	.....
$\text{H}_2\text{O}$	.....	.....

- (iv) Deduce the bond angles in  $\text{SO}_2$  and  $\text{H}_2\text{O}$ .

[1]

$\text{SO}_2$ : .....  $\text{H}_2\text{O}$ : .....
---



1. Phosphine (IUPAC name phosphane) is a hydride of phosphorus, with the formula  $\text{PH}_3$ .

(a) (i) Draw a Lewis (electron dot) structure of phosphine. [1]

(ii) Outline whether you expect the bonds in phosphine to be polar or non-polar, giving a brief reason. [1]

.....

.....

(iii) Explain why the phosphine molecule is not planar. [2]

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(iv) Phosphine has a much greater molar mass than ammonia. Explain why phosphine has a significantly lower boiling point than ammonia. [2]

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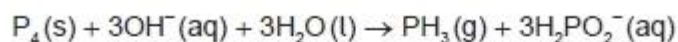
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- (b) Phosphine is usually prepared by heating white phosphorus, one of the allotropes of phosphorus, with concentrated aqueous sodium hydroxide. The equation for the reaction is:



- (i) Identify one other element that has allotropes and list **two** of its allotropes. [2]

Element:

.....

Allotrope 1:

.....

Allotrope 2:

.....

- (ii) The first reagent is written as  $\text{P}_4$ , not  $4\text{P}$ . Describe the difference between  $\text{P}_4$  and  $4\text{P}$ . [1]

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Q#. 6 IB Chem/2012wQ1

- (b) Although the molar masses of  $\text{ICl}$  and  $\text{Br}_2$  are very similar, the boiling point of  $\text{ICl}$  is  $97.4^\circ\text{C}$  and that of  $\text{Br}_2$  is  $58.8^\circ\text{C}$ . Explain the difference in these boiling points in terms of the intermolecular forces present in each liquid. [2]

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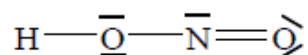
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(ii) The Lewis (electron dot) structure of nitrous acid is given below.



Identify which nitrogen-oxygen bond is the shorter.

[1]

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(iii) Deduce the approximate value of the hydrogen-oxygen-nitrogen bond angle in nitrous acid and explain your answer.

[2]

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(v) Ammonia,  $\text{NH}_3$ , is a weak base. Deduce the Lewis (electron dot) structure of  $\text{NH}_3$ . State the name of the shape of the molecule and explain why  $\text{NH}_3$  is a polar molecule.

[3]

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- (c) (i) Explain why metals are good conductors of electricity and why they are malleable. [2]

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- (ii) Iron is described as a transition metal. Identify the **two** most common ions of iron. [1]

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.....

- (iii) Deduce the chemical formulas of lithium oxide and iron(II) oxide. [1]

Lithium oxide:  
.....  
Iron(II) oxide:  
.....

5. Ethane,  $C_2H_6$ , and disilane,  $Si_2H_6$ , are both hydrides of group 4 elements with similar structures but with different chemical properties.

- (a) (i) Deduce the Lewis (electron dot) structure for  $Si_2H_6$  showing all valence electrons. [1]



(ii) State and explain the H–Si–H bond angle in  $\text{Si}_2\text{H}_6$ . [2]

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(iii) State which of the bonds, Si–H or C–H, is more polar. Explain your choice. [2]

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(iv) Predict, with an explanation, the polarity of the two molecules. [2]

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(v) Explain why disilane has a higher boiling point than ethane. [2]

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B



(ii) Compare the structure and bonding in carbon dioxide and silicon dioxide.

[3]

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Q#. 10 IB Chem/2011/w/tz0/Paper 2 Section B/Standard Level/q5

(c) Phosphorus tribromide ( $\text{PBr}_3$ ) is used to manufacture alprazolam, a drug used to treat anxiety disorders. Methanal ( $\text{HCHO}$ ) is used as a disinfectant.

(i) For each of the species  $\text{PBr}_3$  and  $\text{HCHO}$ :

- deduce the Lewis structure.
- predict the shape and bond angle.

[6]

$\text{PBr}_3$	$\text{HCHO}$
Lewis structure:	Lewis structure:
Shape:	Shape:
.....	.....
Bond angle:	Bond angle:
.....	.....



(ii) Explain why  $\text{PBr}_3$  is a polar molecule.

[2]

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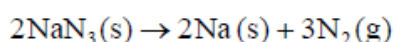
Q#. 11 IB Chem/2011/w/TZ0/Paper 2 Section A/Standard Level/

1. Airbags are an important safety feature in vehicles. Sodium azide, potassium nitrate and silicon dioxide have been used in one design of airbag.



[Source: www.hilalairbag.net]

Sodium azide, a toxic compound, undergoes the following decomposition reaction under certain conditions.



Two students looked at data in a simulated computer-based experiment to determine the volume of nitrogen generated in an airbag.

- (a) Sodium azide involves ionic bonding, and metallic bonding is present in sodium. Describe ionic and metallic bonding.

[2]

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- (c) Describe and compare **three** features of the structure and bonding in the three allotropes of carbon: diamond, graphite and C<sub>60</sub> fullerene.

[6]

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(d) Both silicon and carbon form oxides.

(i) Draw the Lewis structure of  $\text{CO}_2$  and predict its shape and bond angle. [2]

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.....

(ii) Describe the structure and bonding in  $\text{SiO}_2$ . [2]

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(iii) Explain why silicon dioxide is a solid and carbon dioxide is a gas at room temperature. [2]

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(e) Describe the bonding within the carbon monoxide molecule. [2]

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Q#. 14 IB Chem/2010wQ3

- (d) Describe the bonding in iron and explain the electrical conductivity and malleability of the metal. [4]

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Q#. 15 IB Chem/2010/w/tz0/Paper 2 Section B/Standard Level/q4f

- (ii) Predict the value of the H–N–H bond angle in  $\text{N}_2\text{H}_6^{2+}$ . [1]

Q#. 16 IB Chem/2010/w/tz0/Paper 2 Section B/Standard Level/

4. Ethene,  $\text{C}_2\text{H}_4$ , and hydrazine,  $\text{N}_2\text{H}_4$ , are hydrides of adjacent elements in the periodic table.

- (a) (i) Draw Lewis (electron dot) structures for  $\text{C}_2\text{H}_4$  and  $\text{N}_2\text{H}_4$  showing all valence electrons. [2]

- (ii) State and explain the H–C–H bond angle in ethene and the H–N–H bond angle in hydrazine. [5]

- (b) The polarity of a molecule can be explained in terms of electronegativity.

- (i) Define the term *electronegativity*. [2]

- (ii) Compare the relative polarities of the C–H bond in ethene and the N–H bond in hydrazine. [1]

- (iii) Hydrazine is a polar molecule and ethene is non-polar. Explain why ethene is non-polar. [1]

- (c) The boiling point of hydrazine is much higher than that of ethene. Explain this difference in terms of the intermolecular forces in each compound. [2]



Q#. 17 IB Chem/2009/w/TZ0/Paper 2 Section A/Standard Level/

2.  $\text{PF}_3$ ,  $\text{SF}_2$  and  $\text{SiF}_4$  have different shapes. Draw their Lewis structures and use the VSEPR theory to predict the name of the shape of each molecule.

[6]

	$\text{PF}_3$	$\text{SF}_2$	$\text{SiF}_4$
Lewis structure			
Name of shape	.....	.....	.....

Q#. 18 IB Chem/2009/s/tz1/Paper 2 Section B/Standard Level/

6. (a) (i) Draw the Lewis structures for carbon monoxide,  $\text{CO}$ , carbon dioxide,  $\text{CO}_2$  and methanol,  $\text{CH}_3\text{OH}$ .

[3]

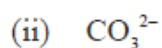
- (ii) List, with an explanation, the three compounds in order of increasing carbon to oxygen bond length (shortest first).

[2]

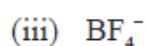
- (b) Predict the shape and bond angles for the following species:



[2]



[2]



[2]

Q#. 19 IB Chem/2009/s/TZ1/Paper 2 Section A/Standard Level/

3. Sodium oxide,  $\text{Na}_2\text{O}$ , is a white solid with a high melting point.

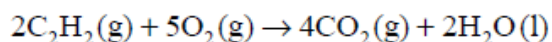
- (a) Explain why solid sodium oxide is a non-conductor of electricity.

[1]

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.....



3. (a) Three types of covalent bond (single, double and triple) are present in the molecules in the following equation.



- (i) Identify **one** bond in these molecules that is correctly described by the following. [4]

A polar single bond .....

A polar double bond .....

A non-polar double bond .....

A non-polar triple bond .....

- (ii) Identify the shortest bond in these molecules. [1]

.....

- (c) Complete the table to show the Lewis structure of each ion and the name of the shape of each ion.

	$\text{NH}_4^+$	$\text{H}_3\text{O}^+$
Lewis structure		
Name of shape		

[4]

6. (a) Draw the Lewis structures of the following molecules. Use the VSEPR theory to predict the shape of each molecule and deduce whether it is polar or non polar.

(i)  $\text{BF}_3$  and  $\text{PCl}_3$  [5]

(ii)  $\text{SO}_2$  and  $\text{CO}_2$  [5]

- (b) State and explain the difference in the following.

(i) The reactivity of Na and K with  $\text{Cl}_2$ . [2]

(ii) The ease of oxidation of  $\text{Br}^-(\text{aq})$  and  $\text{I}^-(\text{aq})$  with  $\text{Cl}_2$ . [2]

(iii) The conductivity of magnesium as compared to sulfur. [2]



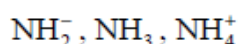
(b) The boiling points of the hydrides of the group 5 elements are shown below:

Hydride	NH <sub>3</sub>	PH <sub>3</sub>	AsH <sub>3</sub>	SbH <sub>3</sub>
Boiling point / K	240	186	218	248

(i) Explain the trend in the boiling points from PH<sub>3</sub> to SbH<sub>3</sub>. [2]

(ii) Explain why the boiling point of NH<sub>3</sub> does not fit this trend. [2]

(c) Arrange the following in **decreasing** order of bond angle (largest one first), and explain your reasoning. [5]



6. (a) State the electron arrangement for atoms of aluminium, nitrogen and fluorine. [2]

(b) Describe the bonding present in samples of solid aluminium and nitrogen gas. [4]

(c) Aluminium fluoride, AlF<sub>3</sub>, is a solid up to a temperature of 1250 °C whereas nitrogen trifluoride, NF<sub>3</sub>, is a gas above -129 °C. Describe the bonding and structure in samples of each of these substances. [5]

(d) Explain why

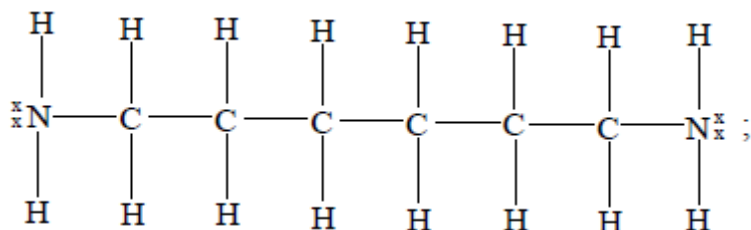
(i) aluminium conducts electricity in both the solid and liquid state. [1]

(ii) aluminium fluoride conducts electricity in the liquid state but not in the solid state. [2]

(iii) nitrogen trifluoride does not conduct in either the liquid or solid states. [1]

(e) Draw the Lewis structure of NCl<sub>3</sub>. Predict, giving a reason, the Cl – N – Cl bond angle in NCl<sub>3</sub>. [3]

This is molecule a and is used in the question that follow/s/TZ1/Paper 2 Section A/Standard Level/



(ii) Use the VSEPR theory to predict the C–C–N bond angle in **A** and identify the shape of the distribution of electron pairs around the carbon atoms. [2]

.....  
.....  
.....  
.....

(c) Identify the strongest type of intermolecular force in **A** and explain how it arises. [3]

.....  
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Q#. 25 IB Chem/2006/w/TZ0/Paper 2 Section A/Standard Level/

3. The elements sodium, aluminium, silicon, phosphorus and sulfur are in period 3 of the periodic table.

(a) Describe the metallic bonding present in aluminium and explain why aluminium has a higher melting point than sodium. [3]

.....  
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.....  
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(d) Explain, by reference to the intermolecular forces, why sulfur has a higher melting point than phosphorus. [2]

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Q#. 26 IB Chem/2005/s/tz1/Paper 2 Section B/Standard Level/q6

- (c) State the type of bonding in the compound  $\text{SiCl}_4$ . Draw the Lewis structure for this compound. [3]
- (d) Outline the principles of the valence shell electron pair repulsion (VSEPR) theory. [3]
- (e) (i) Use the VSEPR theory to predict and explain the shape and the bond angle of each of the molecules  $\text{SCl}_2$  and  $\text{C}_2\text{Cl}_2$ . [6]
- (ii) Deduce whether or not each molecule is polar, giving a reason for your answer. [3]

Q#. 27 IB Chem/2005/s/tz1/Paper 2 Section B/Standard Level/

6. (a) The letters **W**, **X**, **Y** and **Z** represent four consecutive elements in the periodic table. The number of electrons in the highest occupied energy levels are:

**W: 3, X: 4, Y: 5, Z: 6**

Write the formula for

- (i) an ionic compound formed from **W** and **Y**, showing the charges. [2]
- (ii) a covalent compound containing **X** and **Z**. [1]

- (b) State the number of protons, electrons and neutrons in the ion  $^{15}_7\text{N}^{3-}$ . [2]

Q#. 28 IB Chem/2004/w/tz0/Paper 2 Section B/Standard Level/6

- (c) An important compound of nitrogen is ammonia,  $\text{NH}_3$ . The chemistry of ammonia is influenced by its polarity and its ability to form hydrogen bonds. Polarity can be explained in terms of electronegativity.
- (i) Explain the term *electronegativity*. [2]
- (ii) Draw a diagram to show hydrogen bonding between two molecules of  $\text{NH}_3$ . The diagram should include any dipoles and/or lone pairs of electrons [3]
- (iii) State the H—N—H bond angle in an ammonia molecule. [1]
- (iv) Explain why the ammonia molecule is polar. [1]
- (d) Ammonia reacts with hydrogen ions forming ammonium ions,  $\text{NH}_4^+$ .
- (i) State the H—N—H bond angle in an ammonium ion. [1]
- (ii) Explain why the H—N—H bond angle of  $\text{NH}_3$  is different from the H—N—H bond angle of  $\text{NH}_4^+$ ; referring to both species in your answer. [3]

Q#. 29 IB Chem/2004/s/TZ1/Paper 2 Section A/Standard Level/

3. (a) (i) Draw Lewis (electron dot) structures for  $\text{CO}_2$  and  $\text{H}_2\text{S}$  showing all valence electrons. [2]

(ii) State the shape of each molecule and explain your answer in terms of VSEPR theory. [4]

CO<sub>2</sub> .....  
.....  
.....

H<sub>2</sub>S .....  
.....  
.....

(iii) State and explain whether each molecule is polar or non-polar. [2]

.....  
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(b) Identify the strongest type of intermolecular force in each of the following compounds. [3]

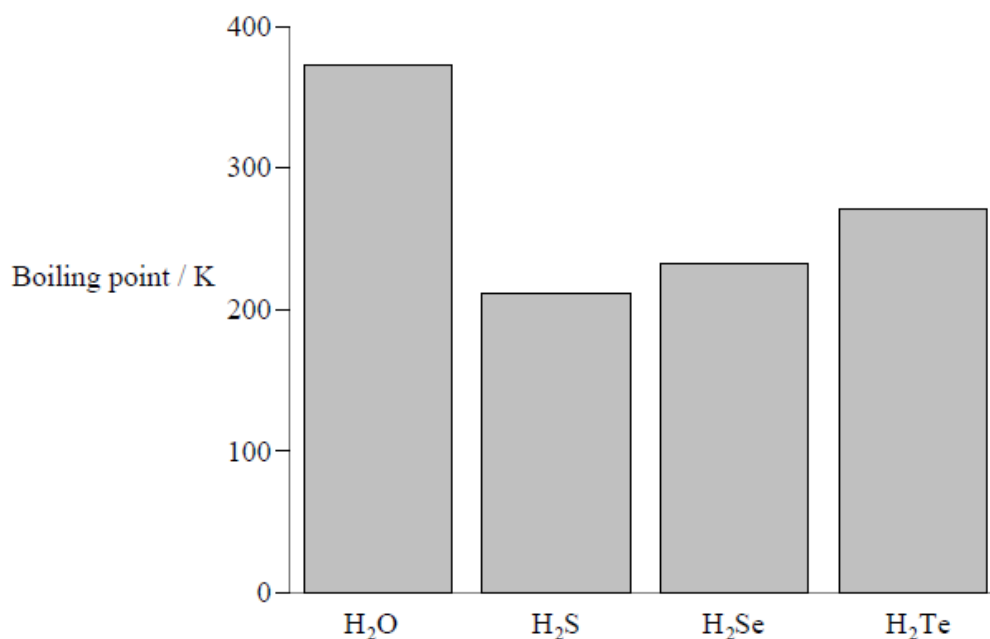
CH<sub>3</sub>Cl .....

CH<sub>4</sub> .....

CH<sub>3</sub>OH .....

Q#. 30 IB Chem/2003/s/tz1/Paper 2 Section B/Standard Level/

6. (a) The boiling points of the hydrides of the group 6 elements are shown below.

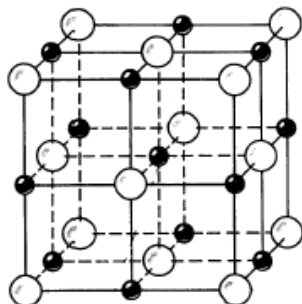


(i) Explain the trend in boiling points from H<sub>2</sub>S to H<sub>2</sub>Te. [2]

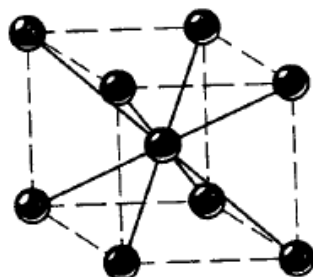
(ii) Explain why the boiling point of water is higher than would be expected from the group trend.

- (b) (i) State the shape of the electron distribution around the oxygen atom in the water molecule and state the shape of the molecule. [2]
- (ii) State and explain the value of the HOH bond angle. [2]
- (c) Explain why the bonds in silicon tetrachloride,  $\text{SiCl}_4$ , are polar, but the molecule is not. [2]

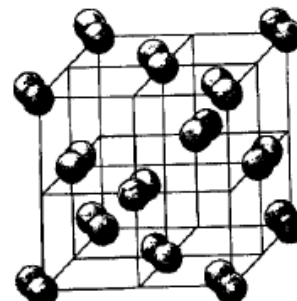
The diagrams below represent the structures of iodine, sodium and sodium iodide.



A



B



C

- (d) (i) Identify which of the structures (A, B and C) correspond to iodine, sodium and sodium iodide. [1]
- (ii) State the type of bonding in each structure. [3]
- (e) (i) Sodium and sodium iodide can both conduct electricity when molten, but only sodium can conduct electricity when solid. Explain this difference in conductivity in terms of the structures of sodium and sodium iodide. [4]
- (ii) Explain the high volatility of iodine compared to sodium and sodium iodide. [2]

Q#. 31 IB Chem/2002/s/tz1/Paper 2 Section B/Standard Level/

6. (a) The elements sodium and fluorine and the compound sodium fluoride can be used to show the connection between bonding, structure and physical properties.
- (i) Describe the type of bonding in sodium metal and explain why sodium is a good conductor of electricity. [4]
- (ii) Draw a Lewis structure for fluorine. Name and describe the bonding within and between the molecules in liquid fluorine. [5]
- (iii) Write the electronic structures of both sodium and fluorine and describe how the atoms combine to form sodium fluoride. [4]
- (iv) Explain why sodium fluoride does not conduct electricity until it is heated above its melting point. [1]
- (b) Sketch and name the shape of each of the following molecules:
- (i)  $\text{SiH}_4$  [2]
- (ii)  $\text{PH}_3$  [2]
- (c) State the bond angle in  $\text{SiH}_4$  and explain why the bond angle in  $\text{PH}_3$  is less than in  $\text{SiH}_4$ . [2]



Q#. 32 IB Chem/2001/w/tz0/Paper 2 Section B/Standard Level/

5. Chlorine forms compounds with both sodium and hydrogen.

- (a) Give the formula of each compound. Describe in terms of electrons, the bonding in each compound and account for the difference. [5]
- (b) Predict and explain the relative melting points of the two compounds. [4]
- (c) Predict and explain the relative electrical conductivities of the two compounds in the solid and liquid states. [3]
- (d) Both compounds are soluble in water. Explain how water is able to dissolve both compounds. [6]
- (e) Explain why carbon tetrachloride,  $\text{CCl}_4$ , does not dissolve in water. [2]

Q#. 33 IB Chem/2001/w/TZ0/Paper 2 Section A/Standard Level/

4. (a) Explain why lead(II) chloride,  $\text{PbCl}_2$ , does not conduct electricity in the solid state but does in the molten state. [2]

.....  
.....  
.....  
.....

(b) Write balanced half-equations, with state symbols, for the reaction at each electrode when molten lead(II) chloride is electrolysed. [2]

Anode (positive electrode): .....

Cathode (negative electrode): .....

Q#. 34 IB Chem/2001/s/tz1/Paper 2 Section B/Standard Level/

6. (a) The electronegativity value of carbon is 2.5 and that of oxygen is 3.5.

(i) Draw a Lewis (electron dot) structure for the carbon dioxide molecule, state its shape and give the bond angle. [3]

(ii) Using the concepts of molecular shape and bond polarity, predict, with an explanation, whether or not the carbon dioxide **molecule** is polar. [3]

Q#. 35 IB Chem/2000/w/tz0/Paper 2 Section B/Standard Level/

6. (a) Give an example of each of the following substances, and use **bonding theories** to describe the interactions between atoms, molecules and/or ions in each:

(i) a polar covalent substance [5]

(ii) a network (giant) covalent solid [3]

(iii) a solid that contains both covalent and ionic bonds. [4]

(b) Draw the molecular shape of aminomethane ( $\text{CH}_3\text{NH}_2$ ), and predict the bond angles around the carbon and nitrogen atoms using the Valence Shell Electron Pair Repulsion (VSEPR) theory. [4]



- (c) Aminomethane and ethane have similar molar masses. Explain why aminomethane has a boiling point of  $-6\text{ }^{\circ}\text{C}$  whereas that of ethane is  $-89\text{ }^{\circ}\text{C}$ .

[4]

Q#. 36 IB Chem/1999/w/TZ0/Paper 2 Section A/Standard Level/

2.  $\text{CCl}_2\text{F}_2$  is no longer used in refrigerators as it can damage the ozone layer.

- (a) Draw the Lewis structure for  $\text{CCl}_2\text{F}_2$ .

[1]

- (b) Predict the shape of a molecule of  $\text{CCl}_2\text{F}_2$ .

[1]

.....  
 .....

- (c) State, giving your reasons, whether a molecule of  $\text{CCl}_2\text{F}_2$  is polar or non-polar.

[2]

.....  
 .....

Q#. 37 IB Chem/1999/s/tz1/Paper 2 Section B/Standard Level/

5. This question refers to chemical bonding.

- (a) Draw electron dot structures for methane, ammonia and water. Use these structures to explain why the molecular bond angles decrease in the order;

methane > ammonia > water

[7]

- (b) Draw electron dot structures for  $\text{N}_2$  and  $\text{F}_2$  and explain why  $\text{F}_2$  is much more reactive than  $\text{N}_2$ .

[3]

- (c) Explain why the melting point of the elements increase in the order;

sodium < magnesium < aluminium < silicon

[5]

- (d) Compare the polarity of the bonds  $\text{N}-\text{Cl}$  and  $\text{C}-\text{Cl}$ . Are the molecules  $\text{NCl}_3$  and  $\text{CCl}_4$  polar or non-polar? In all your answers give your reasons.

[5]

## Mark Scheme IB 4 SL EQ P2 16w to 99s 325marks

Q#. 1 IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q4

4.	f	<p>«3-D/giant» regularly repeating arrangement «of ions»  OR  lattice «of ions» ✓</p> <p>electrostatic attraction between oppositely charged ions  OR  electrostatic attraction between <math>\text{Mg}^{2+}</math> and <math>\text{O}^{2-}</math> ions ✓</p>	<p>Accept "giant" for M1, unless "giant covalent" stated.</p> <p>Do not accept "ionic" without description.</p>	2
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Q#. 2 IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q2

Question	Answers	Notes	Total	
2.	d	<p>electrons delocalized «across the O–C–O system»  OR  resonance occurs ✓</p> <p>122 «pm» &lt; C–O &lt; 143 «pm» ✓</p>	<p>Accept delocalized <math>\pi</math>-bond(s).</p> <p>Accept any answer in the range 123 «pm» to 142 «pm».  Accept "bond intermediate between single and double bond" or "bond order 1.5".</p>	2



Q#. 3 IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q1

1.	c	ethane-1,2-diol can hydrogen bond to other molecules «and ethene cannot» OR ethane-1,2-diol has «significantly» greater van der Waals forces ✓  hydrogen bonding is «significantly» stronger than other intermolecular forces ✓	Accept converse arguments. Award [0] if answer implies covalent bonds are broken.	2
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Q#. 4 IB Chem/2016/SP/TZ0/Paper 2 Section A/Standard Level/Q2

a	ii	<table border="1"> <thead> <tr> <th>Molecule</th> <th>Lewis (electron dot) structure</th> </tr> </thead> <tbody> <tr> <td>SO<sub>2</sub></td> <td> </td> </tr> <tr> <td>H<sub>2</sub>O</td> <td> </td> </tr> </tbody> </table>	Molecule	Lewis (electron dot) structure	SO <sub>2</sub>		H <sub>2</sub> O		Lines, x's or dots may be used to represent electron pairs.	2			
Molecule	Lewis (electron dot) structure												
SO <sub>2</sub>													
H <sub>2</sub> O													
a	iii	<table border="1"> <thead> <tr> <th></th> <th>Electron domain geometry</th> <th>Molecular geometry</th> </tr> </thead> <tbody> <tr> <td>SO<sub>2</sub></td> <td>trigonal/triangular planar</td> <td>bent/v-shaped/angular ✓</td> </tr> <tr> <td>H<sub>2</sub>O</td> <td>tetrahedral</td> <td>bent/v-shaped/angular ✓</td> </tr> </tbody> </table>		Electron domain geometry	Molecular geometry	SO <sub>2</sub>	trigonal/triangular planar	bent/v-shaped/angular ✓	H <sub>2</sub> O	tetrahedral	bent/v-shaped/angular ✓	Award [1 max] for either both electron domain geometries correct OR for either both molecular geometries correct.	2
	Electron domain geometry	Molecular geometry											
SO <sub>2</sub>	trigonal/triangular planar	bent/v-shaped/angular ✓											
H <sub>2</sub> O	tetrahedral	bent/v-shaped/angular ✓											
a	iv	SO <sub>2</sub> : Accept any angle in the range greater than 115° but less than 120° . and H <sub>2</sub> O: 104.5° ✓	Experimental value is 119°	1									

Q#. 5 IB Chem/2016/s/TZ0/Paper 2 Section A/Standard Level/Q1

- 5 -

M16/4/CHEMI/SP2/ENG/TZ0/XX/M

Question	Answers	Notes	Total
1. a i		Accept structures using dots and/or crosses to indicate bonds and/or lone pair.	1
1. a ii	non-polar AND P and H have the same electronegativity ✓	Accept "similar electronegativities". Accept "polar" if there is a reference to a small difference in electronegativity and apply ECF in 1 a (iv).	1
1. a iii	4 electron domains/pairs/negative charge centres «around the central atom» OR a lone/non-bonding pair «and three bonding pairs around the central atom» ✓ repulsion between electron domains/pairs/negative charge centres «produces non-planar shape» OR «repulsion causes» tetrahedral orientation/pyramidal shape ✓		2
1. a iv	PH <sub>3</sub> has London «dispersion» forces ✓  NH <sub>3</sub> forms H-bonds ✓  H-bonds are stronger OR London forces are weaker ✓	Accept van der Waals' forces, dispersion forces and instantaneous dipole – induced dipole forces. Accept "dipole-dipole forces" as molecule is polar. H-bonds in NH <sub>3</sub> (only) must be mentioned to score [2]. Do not award M2 or M3 if: • implies covalent bond is the H-bond • implies covalent bonds break.  Accept "dipole-dipole forces are weaker".	2 max



Question			Answers	Notes	Total
1.	b	i	Element carbon/C ✓ Allotropes <i>Award [1] for two of:</i> diamond graphite graphene C <sub>60</sub> / buckminsterfullerene ✓ OR oxygen/O/O <sub>2</sub> ✓ ozone/O <sub>3</sub> AND <del>diatomic/molecular</del> oxygen/O <sub>2</sub> ✓	Accept two correctly named allotropes of any other named element (S, Se, Sn, As, etc.).  Accept fullerene, "buckyballs" etc. instead of buckminsterfullerene.	2
1.	b	ii	P <sub>4</sub> is a molecule <del>comprising 4P atoms</del> AND 4P is four/separate <del>P</del> atoms OR P <sub>4</sub> represents <del>4P</del> atoms bonded together AND 4P represents <del>4</del> separate/non-bonded <del>P</del> atoms ✓		1

Q#. 6 IB Chem/2012wQ1

- (b) Br<sub>2</sub> has London/dispersion/van der Waals' forces/vdW **and** ICl has (London/dispersion/van der Waals' forces/vdW and) dipole–dipole forces; dipole–dipole forces are stronger than London/dispersion/van der Waals'/vdW forces ;

[2]

*Allow induced dipole-induced dipole forces for London forces.*

*Allow interactions instead of forces.*

*Do not allow ICl polar and Br<sub>2</sub> non-polar for M1.*

*Name of IMF in both molecules is required for M1 and idea of dipole-dipole stronger than vdW is required for M2.*

Q#. 7 IB Chem/2012/w/tz0/Paper 2 Section B/Standard Level/q5b

- (ii) N=O;

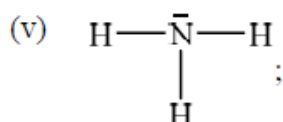
[1]

- (iii) accept any value in range 102 – 105° ;

*Actual value is 102° .*

lone/non-bonding pairs on oxygen occupy more space/repel more than bonding pairs hence decreasing the H–O–N bond angle (from 109.5°) / *OWTTE*;

[2]



*Accept any combination of lines, dots or crosses to represent electron pairs.*

trigonal/triangular pyramidal;

*Accept pyramidal (since SL).*

*Do not allow tetrahedral.*

net dipole moment present in molecule / NH bond polarities do not cancel each other out / unsymmetrical distribution of charge / *OWTTE*;

[3]

*Do not accept molecule has no symmetry hence polar.*

Q#. 8 IB Chem/2012/w/tz0/Paper 2 Section B/Standard Level/q4

- (c) (i) metals have delocalized electrons / sea of electrons which are mobile/can move / *OWTTE*;

layers/positive ions/cations/atoms slide past/over each other / *OWTTE*;

*Do not accept nuclei for M2.*

[2]

- (ii) Fe<sup>2+</sup> **and** Fe<sup>3+</sup> ;

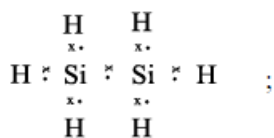
[1]

- (iii) *Lithium oxide*: Li<sub>2</sub>O **and** *Iron(II) oxide*: FeO;

[1]



5. (a) (i)



[1]

*Accept any combination of lines, dots or crosses to represent electron pairs.*

(ii)  $109^\circ / 109.5^\circ / 109^\circ 28'$ ;

four/tetrahedrally arranged negative charge centres/electron domains/electron pairs (around central/silicon atom) / equal repulsion between bonding pairs (around central/silicon atom) / *OWTTE*;

[2]

*M2 is an independent marking point.*

*Reference must be made to negative or electron.*

*Do not accept tetrahedral molecule.*

(iii) C–H;

larger difference in electronegativity (for C–H bond) / smaller difference in electronegativity (for Si–H bond) /  $\Delta\text{EN}(\text{CH}) = 0.4$  **and**  $\Delta\text{EN}(\text{SiH}) = 0.3$ ;

[2]

(iv) both (molecules) non-polar;

both (molecules) symmetrical / polar bond effects cancel out / *OWTTE*;

[2]

(v) stronger/larger/greater van der Waals'/London/dispersion forces;

*Do not accept stronger/larger/greater intermolecular forces.*

more electrons / stronger instantaneous dipole;

[2]

*Do not accept larger mass.*

(b) (i)  $(-1560 \times 2) = -3120$  (kJ);

[1]

(ii) *Structure:*

CO<sub>2</sub> molecular **and** SiO<sub>2</sub> three-dimensional/network/giant lattice/giant covalent/macromolecular/repeating tetrahedral units;

CO<sub>2</sub> linear **and** SiO<sub>2</sub> tetrahedral;

*Intramolecular Bonding:*

covalent bonds in CO<sub>2</sub> **and** SiO<sub>2</sub>;

double bonds in CO<sub>2</sub> **and** single bonds in SiO<sub>2</sub>;

[3 max]

*Accept diagrams showing bonding types (double and single) within the structures.*



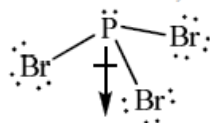
(c) (i)

$PBr_3$	$HCOH$
<p><i>Lewis structure:</i></p> <pre>       :Br—P—Br:               :Br:           </pre> <p>Allow x's, dots or lines to represent electrons. Penalize missing lone pairs on terminal atoms once only for the two Lewis structures.</p> <p><i>Shape:</i> trigonal/triangular pyramidal; Allow pyramidal.</p> <p><i>Bond angle:</i> less than <math>109.5^\circ</math> ; Allow any angle less than <math>109.5^\circ</math> but greater than or equal to <math>100^\circ</math> (experimental value is <math>101^\circ</math>).</p>	<p><i>Lewis structure:</i></p> <pre>       :O:              H—C—H           </pre> <p>Allow x's, dots or lines to represent electrons. Penalize missing lone pairs on terminal atoms once only for the two Lewis structures.</p> <p><i>Shape:</i> trigonal/triangular planar;</p> <p><i>Bond angle:</i> <math>120^\circ</math> ;</p>

[6]

Do not allow ECF in this question from incorrect Lewis structure.

- (ii) Br more electronegative than P / P–Br bond polar;  
bond dipoles do not cancel / there is a net dipole / asymmetric distribution of electron cloud;



[2]

Allow polar bonds do not cancel or that it is an asymmetric molecule.

Award [2] for diagram showing net dipole moment as shown.

1. (a) *Ionic:*

(electrostatic) attraction between oppositely charged ions/cations and anions/positive and negative ions;

Do not accept answers such as compounds containing metal and non-metal are ionic.

*Metallic:*(electrostatic attraction between lattice of) positive ions/cations/nuclei and delocalized electrons / (bed of) positive ions/cations/nuclei in sea of electrons / *OWTTE*;

[2]

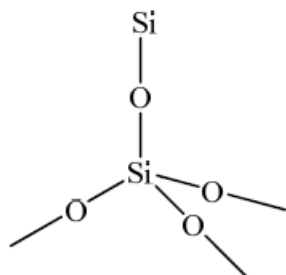
- (c) (i) sodium could react violently with any moisture present / sodium is (potentially) explosive / sodium (is dangerous since it is flammable when it) forms hydrogen on contact with water / *OWTTE*;

[1]

Do not accept answers such as sodium is dangerous or sodium is too reactive.



- (ii) *Structure:*  
drawing of giant structure showing tetrahedrally arranged silicon;  
*Minimum information required for mark is Si and 4 O atoms, in a tetrahedral arrangement (not 90° bond angles) but with each of the 4 O atoms showing an extension bond.*



*Bonding:*  
(giant/network/3D) covalent;

[2]

Q#. 13 IB Chem/2011/s/tz1/Paper 2 Section B/Standard Level/q7

- (c) *Award [2 max] for three of the following features:*

*Bonding*

*Graphite and C<sub>60</sub> fullerene:* covalent bonds **and** van der Waals'/London/dispersion forces;

*Diamond:* covalent bonds (and van der Waals'/London/dispersion forces);

*Delocalized electrons*

*Graphite and C<sub>60</sub> fullerene:* delocalized electrons;

*Diamond:* no delocalized electrons;

*Structure*

*Diamond:* network/giant structure / macromolecular / three-dimensional structure **and** *Graphite:* layered structure / two-dimensional structure / planar;

*C<sub>60</sub> fullerene:* consists of molecules / spheres made of atoms arranged in hexagons/pentagons;

*Bond angles*

*Graphite:* 120° **and** *Diamond:* 109°;

*C<sub>60</sub> fullerene:* bond angles between 109–120°;

*Allow Graphite:* sp<sup>2</sup> **and** *Diamond:* sp<sup>3</sup>.

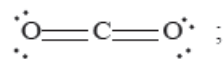
*Allow C<sub>60</sub> fullerene:* sp<sup>2</sup> **and** sp<sup>3</sup>.

*Number of atoms each carbon is bonded to*

*Graphite and C<sub>60</sub> fullerene:* each C atom attached to 3 others;

*Diamond:* each C atom attached to 4 atoms / tetrahedral arrangement of C (atoms); [6 max]

- (d) (i)



linear **and** 180°;

*Accept crosses, lines or dots as electron pairs.*

[2]

- (ii) network/giant structure / macromolecular;  
each Si atom bonded covalently to 4 oxygen atoms **and** each O atom bonded covalently to 2 Si atoms / single covalent bonds;

*Award [1 max] for answers such as network-covalent, giant-covalent or macromolecular-covalent.*

*Both M1 and M2 can be scored by a suitable diagram.*

[2]



(iii) *Silicon dioxide*: strong/covalent bonds in network/giant structure/macromolecule;  
*Carbon dioxide*: weak/van der Waals'/dispersion/London forces between molecules; [2]

(e) triple (covalent) bond;  
 one electron pair donated by oxygen to carbon atom / dative (covalent)/coordinate (covalent) bond; [2]  
*Award [1 max] for representation of C≡O.*  
*Award [2] if CO shown with dative covalent bond.*

Q#. 14 IB Chem/2010wQ3

(d) metallic (bonding);  
 positive ions/cations **and** delocalized/sea of electrons;  
 electrostatic attraction between the two;  
*Award [2 max] for description of bonding*  
*Conductivity:*  
 electrons delocalised/free to move;  
*Malleability:*  
 atoms/ions/cations can move without breaking bonds / atoms/ions/cations can slide past each other; [4]

Q#. 15 IB Chem/2010/w/tz0/Paper 2 Section B/Standard Level/q4f

(ii) 109°/109.5°; [1]

Q#. 16 IB Chem/2010/w/tz0/Paper 2 Section B/Standard Level/

4. (a) (i) 
$$\begin{array}{ccc} \text{H} & & \text{H} \\ & \times & \times \\ & \times & \times \\ \times & \times & \times \\ \text{C} & \times & \text{C} \\ & \times & \times \\ \text{H} & & \text{H} \end{array};$$
  

$$\begin{array}{ccc} & \text{H} & \\ & \times & \\ \text{H} & \times & \times \\ \times & \times & \times \\ \text{N} & \times & \text{N} \\ & \times & \times \\ & \text{H} & \end{array};$$
  
*Accept x's, dots or lines for electron pairs.* [2]

(ii) *H-C-H*:  
 any angle between 118° and 122°;  
 due to three negative charge centres/electron domains/electron pairs;  
*H-N-H*:  
 any angle between 104° and 108°;  
 due to four negative charge centres/electron domains/electron pairs;  
 extra repulsion due to lone electron pairs; [5]  
*Do not allow ECF for wrong Lewis structures.*

(b) (i) (relative) measure of an atoms attraction for electrons;  
 in a covalent bond / shared pair; [2]

(ii) C-H is less polar as C is less electronegative / N-H bond is more polar as N is more electronegative / difference in electronegativity is greater for N-H than C-H; [1]

(iii) bond polarities cancel in C<sub>2</sub>H<sub>4</sub> / *OWTTE*; [1]



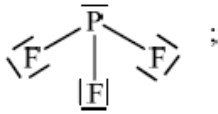
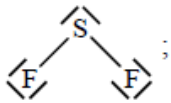
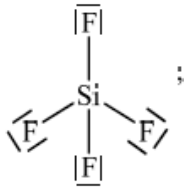


- (c) weaker van der Waals'/London/dispersion/intermolecular forces in ethene;  
stronger (intermolecular) hydrogen bonding in hydrazine;  
*If no comparison between strengths then [1 max].*

[2]

Q#. 17 IB Chem/2009/w/TZ0/Paper 2 Section A/Standard Level/

2.

	PF <sub>3</sub>	SF <sub>2</sub>	SiF <sub>4</sub>
Lewis structure	 ; <i>1 lone pair on P required for the mark</i>	 ; <i>2 lone pairs on S required for the mark</i>	 ;
Name of shape	trigonal/triangular pyramidal;	bent/angular/V shaped;	tetrahedral/tetrahedron;

[6]

*Penalise missing lone pairs on fluorine atoms once in correct structures only.*

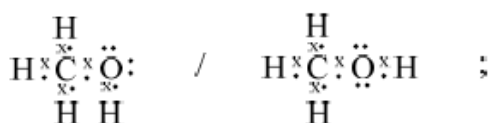
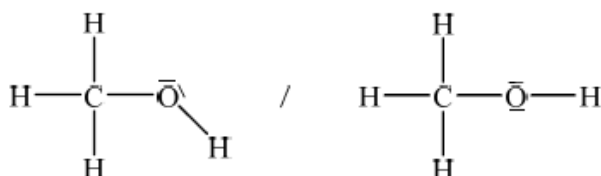
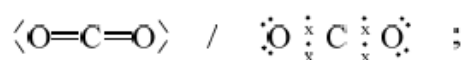
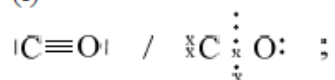
*For Lewis structures candidates are not expected to draw exact shapes of molecules.*

*Do not allow ECF for wrong Lewis structures.*

*Accept dots or crosses instead of lines.*

Q#. 18 IB Chem/2009/s/tz1/Paper 2 Section B/Standard Level/

6. (a) (i)



[3]

*All outer electron pairs must be shown for mark in each case.*

*Accept electrons shown as all x rather than • and x.*

(ii) CO < CO<sub>2</sub> < CH<sub>3</sub>OH;

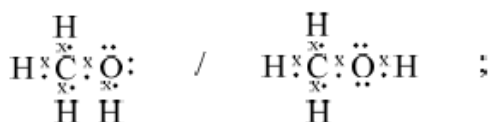
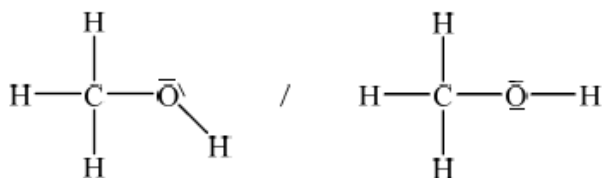
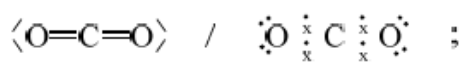
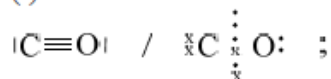
triple bonds are shorter than double bonds which are shorter than single bonds /  
the more pairs of electrons that are shared the stronger the attracting so the  
shorter the bond / *OWTTE*;

*The order must be correct to gain the second marking point unless ECF  
from (a).*

[2]



6. (a) (i)



[3]

*All outer electron pairs must be shown for mark in each case.*

*Accept electrons shown as all x rather than • and x.*

(ii)  $\text{CO} < \text{CO}_2 < \text{CH}_3\text{OH}$ ;

triple bonds are shorter than double bonds which are shorter than single bonds / the more pairs of electrons that are shared the stronger the attracting so the shorter the bond / *OWTTE*;

[2]

*The order must be correct to gain the second marking point unless ECF from (a).*

(b) (i) ( $\text{CO}_2$ ) linear;  
180°;

[2]

(ii) ( $\text{CO}_3^{2-}$ ) trigonal planar/triangular planar;  
120°;

[2]

(iii) ( $\text{BF}_4^-$ ) tetrahedral;  
109.5° / 109° / 109° 28';

[2]

Q#. 19 IB Chem/2009/s/TZ1/Paper 2 Section A/Standard Level/

3. (a) in the solid state ions are in fixed positions/there are no moveable ions / *OWTTE*;  
*Do not accept answer that refers to atoms or molecules.*

[1]

Q#. 20 IB Chem/2008/w/TZ0/Paper 2 Section A/Standard Level/

3. (a) (i) *polar single*  
O–H;  
*Accept C–H, H<sub>2</sub>O*

*polar double*  
C=O;  
*Accept CO<sub>2</sub>*

*non-polar double*  
O=O;  
*Accept O<sub>2</sub>*

*non-polar triple*  
C≡C/triple carbon bond / O–H;

[4]

(ii) C≡C/triple carbon bond;

[1]



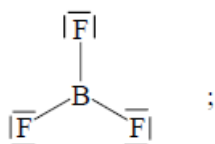
(c)

	$\text{NH}_4^+$	$\text{H}_3\text{O}^+$
Lewis structure	$\left[ \begin{array}{c} \text{H} \\   \\ \text{H}-\text{N}-\text{H} \\   \\ \text{H} \end{array} \right]^+$	$\left[ \begin{array}{c} \text{H}-\overset{\ominus}{\text{O}}-\text{H} \\   \\ \text{H} \end{array} \right]^+$
	<i>Accept two dots or two crosses or one of each instead of — No penalty for missing + signs.</i>	
Name of shape	tetrahedral;	trigonal/triangular pyramidal/pyramidal;

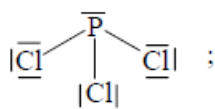
[4]

Q#. 21 IB Chem/2008/s/tz1/Paper 2 Section B/Standard Level/

6. (a) (i)



trigonal planar;

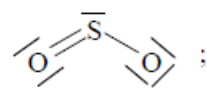


(trigonal) pyramidal;

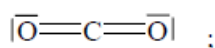
 $\text{BF}_3$  non-polar **and**  $\text{PCl}_3$  polar;

[5]

(ii)



angular/bent/v-shaped;



linear;

 $\text{SO}_2$  polar **and**  $\text{CO}_2$  non polar;

[5]

*Do not allow ECF from wrong Lewis structures.**Penalize missing lone pairs on fluorine, oxygen and chlorine once only.**Penalize missing or extra lone pairs on central atom every time.*(b) (i) K more reactive / Na less reactive;  
easier to remove electron from K / lower IE;

[2]

(ii)  $\text{I}^-$  more easily oxidised /  $\text{Br}^-$  less easily oxidized;  
easier to remove electron from  $\text{I}^-$ ;

[2]

(iii) Mg conductor/S non-conductor;  
Mg's sea of/delocalised electrons free to move, whereas S's electrons are covalently bonded/not free to move;

[2]



Q#. 22 IB Chem/2007/w/tz0/Paper 2 Section B/Standard Level/

(b) (i) molecules become larger / size increases / number of  $e^-$  increases / become heavier /  $M_r$  increases;  
van der Waals'/London/dispersion forces increase; [2]

(ii) hydrogen bonding between  $\text{NH}_3$  molecules;  
which is stronger than van der Waals' forces;  
higher value than expected; [2 max]

(c)  $\text{NH}_4^+ > \text{NH}_3 > \text{NH}_2^-$ ;  
 $\text{NH}_4^+$  has four bonded electron pairs (and no lone electron pairs);  
 $\text{NH}_3$  has three bonded electron pairs and one electron lone pair;  
 $\text{NH}_2^-$  has two bonded electron pairs and two electron lone pairs;  
*Accept correct Lewis structures with lone electron pairs clearly shown.*

lone pair-lone pair > lone pair-bonded pair > bonded pair-bonded pair / lone pairs of electrons repel more than bonding pairs of electrons / *OWTTE*;  
*Do not accept repulsion between atoms.* [5]

Q#. 23 IB Chem/2007/s/tz1/Paper 2 Section B/Standard Level/

6. (a) Al – 2,8,3;  
N – 2,5;  
F – 2,7; [2 max]  
*Award [2] for three correct, [1] for two or one correct.*  
*Accept correct configuration using s,p,d notation.*

(b) aluminium  
metallic bonding;  
positive ions/  $\text{Al}^{3+}$  ions in a sea of / delocalized (valence) electrons;  
nitrogen,  $\text{N}_2$   
covalent/triple bond between nitrogen atoms;  
van der Waals' forces between the molecules; [4]

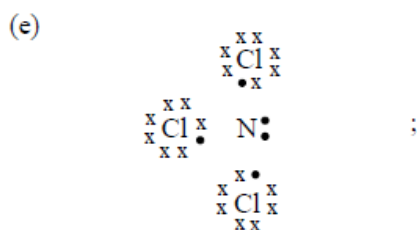
(c)  $\text{AlF}_3$   
giant / 3-dimensional ionic lattice;  
strong ionic bonds / attraction between  $\text{Al}^{3+}$  and  $\text{F}^-$  ions;  
 $\text{NF}_3$   
simple molecular structure / strong covalent bonds within molecules;  
weak(er) forces between molecules;  
dipole-dipole / van der Waals' / London forces; [5]

(d) (i) electrons delocalized/move through structure in both the solid and liquid state; [1]

(ii) free moving ions in liquid state;  
ions fixed in position in solid state; [2]

(iii) no free moving charged particles / no ions and no electrons to carry charge; [1]





All electrons must be shown.

Accept molecular structures using lines to represent bonding and lone electron pairs.

bond angle:  $107^\circ - 109^\circ$ ;

greater repulsion between lone pair and bonding pairs / OWTTE; [3]  
 NOT between electron pairs and atoms.

Award [1 max] if lone pair missed on nitrogen, ECF for bond angle of  $120^\circ$ .

Q#. 24 IB Chem/2006/w/TZ0/Paper 2 Section A/Standard Level/

(ii)  $109.5^\circ / 109^\circ$ ;  
 tetrahedral; [2]

(c) hydrogen bonding;

N more electronegative than H / N-H bond (very) polar;  
 (strong) attraction between N of one molecule and H of another molecule; [3]

Q#. 25 IB Chem/2006/w/TZ0/Paper 2 Section A/Standard Level/

3. (a) delocalized electrons;  
 (attracted) to positive ions;  
 more delocalized / mobile / outer shell electrons / higher ionic charge; [3]

(d) stronger van der Waals'/London/dispersion forces;  
 (sulfur has) bigger  $M_r$  /  $S_8$  compared with  $P_4$  /  $S_8$  has a larger molar mass than  $P_4$  / more electrons; [2]

Q#. 26 IB Chem/2005/s/tz1/Paper 2 Section B/Standard Level/q6

(c) Si—Cl bonds are covalent;



Accept lines for electron pairs.

Award [1] for covalent bonds and [1] for lone pairs.

(d) find number of electron pairs/charge centres in (valence shell of) central atom;  
 electron pairs/charge centres (in valence shell) of central atom repel each other;  
 to positions of minimum energy/repulsion / maximum stability;  
 pairs forming a double or triple bond act as a single bond;  
 non-bonding pairs repel more than bonding pairs / OWTTE; [3 max]  
 Do not accept repulsion between bonds or atoms.  
 Award [1] each for any three points.



- (e) (i)  $\text{SCl}_2$  two bonding pairs, two non-bonding pairs;  
angular / bent / non-linear / V-shaped;  
*Both these marks can be scored from a diagram.*  
 $90^\circ < \text{angle} < 107^\circ$ ;
- $\text{C}_2\text{Cl}_2$  two charge centres around each C;  
linear;  
*Both these marks can be scored from a diagram*  
angle =  $180^\circ$ ; [6]

- (ii)  $\text{SCl}_2$  is polar;  
 $\text{C}_2\text{Cl}_2$  is non-polar;  
No net dipole movement for  $\text{C}_2\text{Cl}_2$  but angular  $\text{SCl}_2$  has a resultant dipole *OWTTE*;  
*Mark can be scored from a diagram.* [3]  
*Allow ECF based on the answers given to (i).*

Q#. 27 IB Chem/2005/s/tz1/Paper 2 Section B/Standard Level/

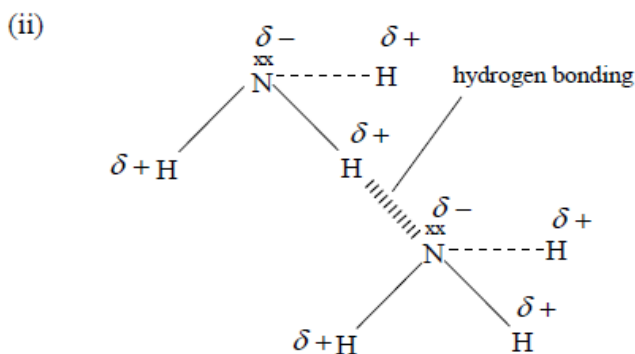
6. (a) (i)  $\text{W}^{3+}\text{Y}^{3-}$ ;  
*Award [1] for formula (WY) and [1] for charges (W:3+Y:3-)* [2]  
*Accept WY, charges W: 3+ Y: 3- for [2].*  
*Answers must be in terms of W and Y.*

- (ii)  $\text{XZ}_2$ ; [1]  
*Accept XZ.*  
*Answers must be in terms of X and Z.*

- (b) 7 protons, 8 neutrons, 10 electrons; [2]  
*Award [2] for three correct and [1] for two correct.*

Q#. 28 IB Chem/2004/w/tz0/Paper 2 Section B/Standard Level/

- (c) (i) (relative) measure of an atom's attraction for electrons;  
in a bond; [2]



- Suitable diagram indicating*  
dipoles;  
lone pairs of electrons;  
hydrogen bonding; [3]

- (iii)  $107^\circ$ ; [1]  
*Accept answer in range 107 to  $109^\circ$ .*
- (iv) molecule is asymmetrical / *OWTTE*; [1]

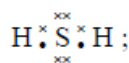


(d) (i)  $109.5^\circ$ ; [1]

(ii)  $\text{NH}_4^+$  has four bonding pairs (around central atom so is a regular tetrahedron);  
 $\text{NH}_3$  has three bonding pairs (of electrons) and one non-bonding pair;  
non-bonding pairs (of electrons) exert a greater repulsive force; [3]  
*Accept suitable diagrams.*

Q#. 29 IB Chem/2004/s/TZ1/Paper 2 Section A/Standard Level/

3. (a) (i)  $\begin{array}{c} \times \times \\ \text{O} : : \text{C} : : \text{O} \\ \times \times \quad \times \times \end{array}$ ; [2]



*Accept dots, crosses, a combination of dots and crosses or a line to represent a pair of electrons.*

(ii)  $\text{CO}_2$  is linear;  
two charge centres or bonds and no lone pairs (around C);  
 $\text{H}_2\text{S}$  is bent / v-shaped / angular;  
two bond pairs, two lone pairs (around S); [4]

(iii)  $\text{CO}_2$  is non-polar,  $\text{H}_2\text{S}$  is polar;  
bond polarities cancel  $\text{CO}_2$  but not in  $\text{H}_2\text{S}$ ; [2]

(b)  $\text{CH}_3\text{Cl}$  – dipole-dipole attractions;  
 $\text{CH}_4$  – van der Waals' / dispersion / London forces;  
 $\text{CH}_3\text{OH}$  – hydrogen bond; [3]

Q#. 30 IB Chem/2003/s/tz1/Paper 2 Section B/Standard Level/

6. (a) (i) as molecules become larger / heavier / have higher  $M_r$  values / number of electrons increases;  
van der Waals' / London / dispersion forces increase; [2]

(ii) hydrogen bonding **between molecules** in  $\text{H}_2\text{O}$ ;  
this bonding is stronger (than van der Waals' forces); [2]  
*Must be an implied comparison with 6 (a) (i)*

(b) (i) tetrahedral (*accept correct 3-D diagram*);  
bent / V-shape / angular (*accept suitable diagram*); [2]

(ii)  $105^\circ$  (*accept 103 – 106°*);  
lone pairs **repel** each other more than bonding pairs;  
*Do not accept repulsion of atoms.* [2]

(c) bonds are polar as Cl more electronegative than Si;  
*Allow "electronegativities are different"*  
molecule is symmetrical, hence polar effects cancel out / *OWTTE*; [2]

(d) (i) A – sodium iodide, B – sodium, C – iodine (*three correct [1]*);  
*Accept correct formulas.* [1]

(ii) A – ionic bonding;  
B – metallic bonding;  
C – van der Waals' forces (and covalent bonding); [3]



- (e) (i) (for Na) (lattice of) positive ions / atoms;  
delocalized / free electrons / sea of electrons;  
  
(for NaI) oppositely charged ions / positive and negative ions;  
free to move (only) in molten state; [4]

- (ii) forces between  $I_2$  molecules are weak;  
ionic / metallic bonding strong(er); [2]

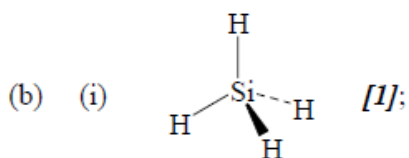
Q#. 31 IB Chem/2002/s/tz1/Paper 2 Section B/Standard Level/

6. (a) (i) positive ions (*not nuclei*) [1];  
delocalised/sea of electrons [1];  
electrostatic attraction between the two [1];  
electrons free to move [1].  
*Any mention of negative ions, first three marks lost.* [4]

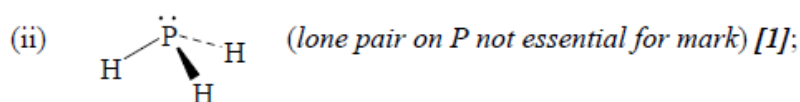
- (ii)  $:\ddot{F}:\ddot{F}:$  (allow  $\times$  or  $\bullet$ , accept  $|\ddot{F} - \ddot{F}|$ ) [1];  
covalent [1];  
shared pairs of electrons [1];  
van der Waals' / dispersion / London forces [1];  
attraction between temporary / fluctuating / oscillating / induced dipoles [1]. [5]

- (iii) sodium 2,8,1 (or diagram or spdf) [1];  
fluorine 2,7 (or diagram or spdf) [1];  
sodium's outer electron transfers to fluorine [1];  
oppositely charged ions / ions formed with complete octets of electrons [1]. [4]

- (iv) Ions not free to move in solid / can move in molten state [1]



tetrahedral [1]. [2]



pyramidal [1]. [2]

*Dotted line and wedge in structures in (i) and (ii) are not essential, as long as 3-D shapes are implied.*

- (c)  $109^\circ - 109.5^\circ$  [1];  
non-bonding pairs repel more than bonding pairs [1].  
*Do not allow non-bonding pairs repel atoms.* [2]



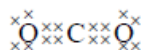


5. (a) NaCl; HCl (*need both for mark*) [1]
- NaCl: Each Na atom **transfers** an electron to each Cl atom [1]  
 thus producing  $\text{Na}^+$  and  $\text{Cl}^-$  / cations and anions with (strong) attraction [1]  
 between oppositely charged ions. [1]
- HCl: Each H atom **shares** an electron with an electron from each Cl (thus [1]  
 producing a covalent bond in which bonding electrons are under the influence [1]  
 of both nuclei).  
 Due to difference in electronegativity / large difference: ionic / smaller [1]  
 difference: covalent. [1]
- (b) NaCl will have a **much higher** melting point than HCl. [1]
- Ionic bonding is a network / 3D arrangement of oppositely charged ions [1]  
 attracting each other strongly. [1]
- HCl is polar (simple molecular) substance with weaker dipole–dipole interaction [1]  
 between molecules. [1]
- (c) Neither will conduct in the solid state because there are no (mobile) ions present. [1]  
 NaCl conducts in the liquid state as ions can move (thus carrying charge). [1]  
 HCl liquid will not conduct as there are no (mobile) ions (or free electrons). [1]
- (d) Water is a highly polar molecule (with  $\text{H}^{\delta+}$  and  $\text{O}^{\delta-}$  ends). [1]
- The  $\delta^-$  of the water surrounds the  $\text{Na}^+$  ions, and the  $\delta^+$  of the water surrounds the  $\text{Cl}^-$  [1]  
 ions / OWTTE. [1]  
 The resulting (dipole–ion) attraction overcomes the attractive forces between the ions, [1]  
 and the compound dissolves. [1]
- HCl is a polar molecule (due to different electronegativities). [1]  
 Polar water molecules surround HCl (in a similar way), [1]  
 and the dipole–dipole attractions are sufficient to break the HCl covalent bond. [1]
- (e)  $\text{CCl}_4$  is a non-polar molecule. [1]  
 There is no possibility of any  $\text{CCl}_4 - \text{H}_2\text{O}$  interactions to compensate for breaking [1]  
 water–water interactions. [1]
- Q#. 33 IB Chem/2001/w/TZ0/Paper 2 Section A/Standard Level/
4. (a) Solid: No **ions** to move about. [1]  
 Molten: Ions are free to move about. [1]
- (b) Anode:  $2\text{Cl}^-(\text{l}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$  (*state symbols needed*) [1]  
 Cathode:  $\text{Pb}^{2+}(\text{l}) + 2\text{e}^- \rightarrow \text{Pb}(\text{l})$  (*state symbols needed*) [1]



Q#. 34 IB Chem/2001/s/tz1/Paper 2 Section B/Standard Level/

6. (a) (i) Correct Lewis diagram **all** valency  $e^-$  must be shown (*lines for lone pairs are acceptable*) [1]



Linear [1]

$180^\circ$  [1]

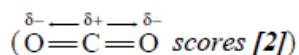
[3 max]

- (ii) Diagram or statement showing O more electronegative than C [1]  
(Accept C-O bond is polar)

Cancelling out of effect [1]

Molecule not polar [1]

[3 max]



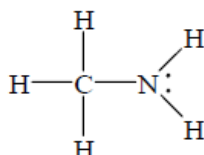
Q#. 35 IB Chem/2000/w/tz0/Paper 2 Section B/Standard Level/

6. (a) (i) Example:  $\text{H}_2\text{O}$  /  $\text{NH}_3$  /  $\text{HF}$  etc. [1]  
Electrons shared unequally [1]  
Different electronegativities [1]  
polar bonds [1]  
dipole–dipole interaction between molecules [1]

- (ii) Diamond or  $\text{SiO}_2$  or  $\text{SiC}$  or  $\text{Si}$  or graphite. [1]  
covalent bonding [1]  
present throughout the structure / involving all atoms (*OWTTE*) [1]

- (iii)  $\text{NH}_4\text{Cl}$  or  $\text{Na}_2\text{CO}_3$  etc. [1]  
Covalent bonding **within**  $\text{NH}_4^+$ ,  $\text{CO}_3^-$  or... [1]  
Electrostatic interaction **between** oppositely charged ions. [1]  
Three-dimensional (or 3-D) lattice / network solid [1]

(b)



$109\frac{1}{2}^\circ$  (around the carbon). [1]

Four electron pairs / charge centres arranged as **far apart as possible** / repel equally [1]

$107^\circ$  / less than  $109^\circ$  (around N) [1]

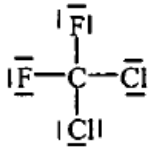
Lone pair of electrons (on N) repels more strongly. [1]

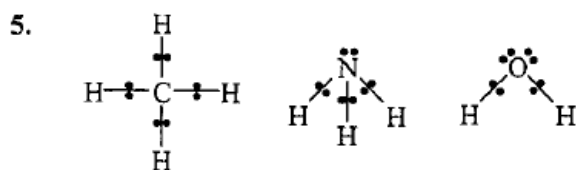
- (c) Ethane: non-polar bonds [1]  
experiences **only weak** van der Waal's forces. [1]

Aminoethane: polar N—H bonds [1]  
so has H—bonding as well [1]

(If answer implies aminoethane is polar and has dipole–dipole interaction then award only [1].)



2. (a)  or 'dot and cross' diagram [1]
- (b) Tetrahedral (as 4 bonding pairs around C atom). [1]
- (c) It will be polar because:  
F is more electronegative than Cl [1]
- OR**
- The resultant dipole of the two C-F bonds will make it polar [1]



All valence e<sup>-</sup>s should be shown for [3 marks]. Award [1 mark] if only lone pairs shown in NH<sub>3</sub> and H<sub>2</sub>O

[3 marks]

- (a) electrons initially arranged **tetrahedrally**/methane is **tetrahedral** [1 mark]  
lone pairs repel more than bonded pairs [1 mark]  
NH<sub>3</sub> has **1 lone pair** so angle < 109.5 (tetrahedral) (≈107°) [1 mark]  
H<sub>2</sub>O has **2 lone pairs** so angle < NH<sub>3</sub> (≈105°) [1 mark]

- (b)  [2 marks]

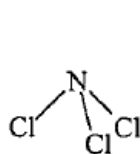
all valence e<sup>-</sup>s should be shown for [2 marks].

Triple bond is stronger/more difficult to break [1 mark]

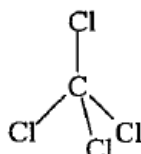
- (c) Na, Mg, Al (ignore Si if included) have free/sea of electrons and show metallic properties/holding the ions together  
Na has 1, Mg 2, Al 3 ('free' electrons)  
So strength of bonding increases  
Si has a **giant covalent/macromolecular structure** which is very difficult to break down with so many bonds

any five [1 mark] each [5 marks]

- (d) C-Cl is more polar than N-Cl [1 mark]  
N is more electronegative than C [1 mark]



is polar



is non-polar

[1 mark] each

[2 marks]

The NCl<sub>3</sub> molecule is not symmetrical/CCl<sub>4</sub> is symmetrical

[1 mark]

[Total 20 marks]

