Exam Papers Practice

4.1 Ionic & Covalent Bonding

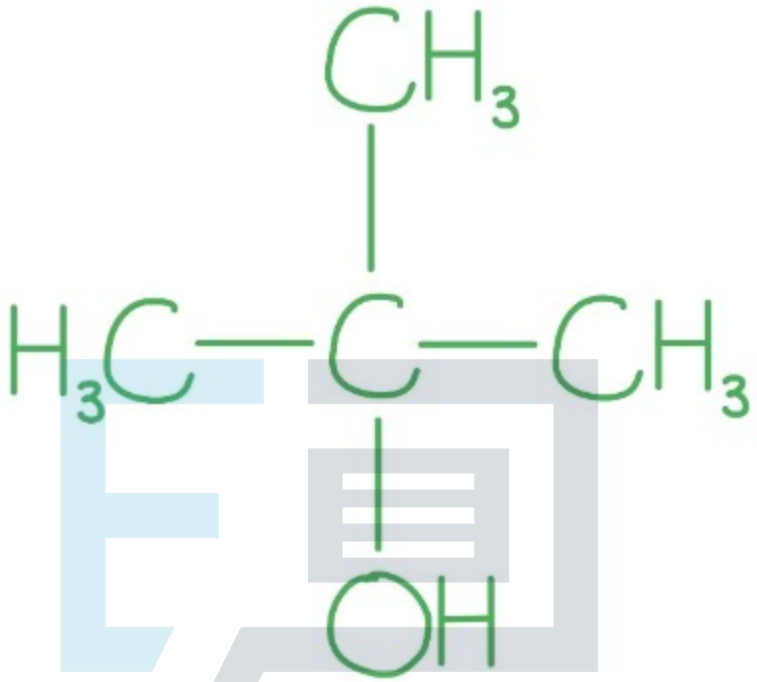
Mark Schemes

Course	DP IB Chemistry
Section	4. Chemical Bonding & Structure
Topic	4.1 Ionic & Covalent Bonding
Difficulty	Medium

To be used by all students preparing for DP IB Chemistry HL
Students of other boards may also find this useful

1

The correct answer is **C** because:

- 

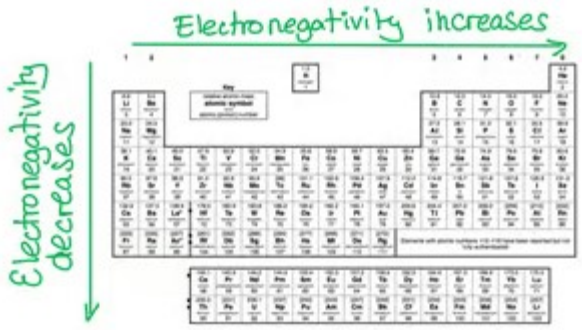
- Statement I
  - This is incorrect as 2–methylpropan-2–ol, $CH_3C(CH_3)(OH)CH_3$, does not contain 16 pair of bonding electrons as there are also lone pairs of electrons present in this structure
  - There is a total of 32 electrons in the structure
  - 3 C-C bonds = 3 pairs (leaves 26 electrons)
  - 1 C-O bond = 1 pair (leaves 24 electrons)
  - 9 C-H bonds = 9 pairs (leaves 6 electrons)
  - 1 O-H bond = 1 pair (leaves 4 electrons), therefore there are 2 lone pairs of electrons on the oxygen atom remaining
- Statement II
  - This is correct as the structure exhibits a tetrahedral shape which has a bond angle of 109.5 °
- Statement III
  - This is correct, there are 32 electrons in total
  - 4 C atoms = 4 x 4
  - 10 H atoms = 10 x 1
  - 1 O atom = 1 x 6
  - Total = 32

A, B & **D** are incorrect as	these include statement 1 which is incorrect

2

The correct answer is **A** because:

- All of the molecules shown in the question are isomers of $C_4H_6Cl_2$
- Chlorine is the most electronegative atom in the molecule
- The electronegativity increases as you move to the right of the periodic table
- The electronegativity decreases as you move down the periodic table
- The electronegativity of chlorine is 3.16



- Electrons in a polar covalent bond are shifted toward the more electronegative atom
- 1,1–dichloro-1–butene is the structure in answer **A**; this has both of the chlorine atoms on one side of the double bond attached to one carbon atom pulling the electrons to that side of the molecule

In the other structures shown the chlorine atoms are further away from each other in the molecule creating less polarity at one point in the molecule

3

The correct answer is **D** because:

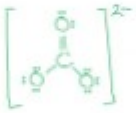
- This is the correct order of increasing polarity
- We can work this out by calculating the difference between the electronegativity of the two atoms
  - P and H = 2.1 - 2.1 = 0
  - P and F = 4.0 - 2.1 = 1.9
  - N and H = 3.0 - 2.1 = 0.9
  - N and F = 4.0 - 3.0 = 1.0
- The greatest difference in electronegativity is between P and F, therefore PF_3 is the most polar molecule
- The smallest difference in electronegativity is between P and H, therefore PH_3 is the least polar molecule
- It can be easy to think that the inclusion of F in a molecule instantly makes it the most polar, but it is the difference in electronegativity between the atoms which causes polarity

A, **B** & **C** are incorrect as	the compounds are not in the correct order of electronegativity

4

The correct answer is **B** because:

- There is an ionic bond between the potassium ion, K^+, and the carbonate ion CO_3^{2-}
- The carbonate ion contains covalent bonds between carbon and oxygen:



A is incorrect as	calcium is a metal and bromine is a non-metal so there are only ionic bonds present
C and **D** are incorrect as	there are only non-metal elements present so there will only be covalent bonds in these molecules

5

The correct answer is **C** because:

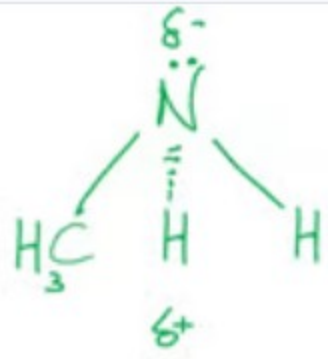
- Ionic bonding occurs when oppositely charged ions attract each other
- The bonding is electrostatic because the charged ions are fixed and do not move

A is incorrect as	this is a description of metallic bonding
B is incorrect as	nuclei are positively charged, so would repel not attract each other
D is incorrect as	this is a description of covalent bonding

6

The correct answer is **A** because:

- To be polar, a molecule must contain polar bonds and be asymmetrical
- The CH_3NH_2 molecule contains polar bonds and is asymmetrical
- Nitrogen is an electronegative element and pulls electron density towards itself
- The uneven distribution of electron density results in the molecule being polar



B is incorrect as	The methane molecule does not contain any polar bonds
C is incorrect as	although the C-Cl bond is very polar, the molecule is a tetrahedral shape so the dipoles are cancelled out and the molecule is non-polar overall
D is incorrect as	the C=O bond is polar, but the molecule is linear so the dipoles cancel out and the molecule is non-polar

7

The correct answer is **C** because:

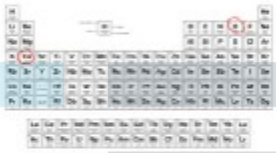
- Ionic compounds can only conduct electricity once melted (molten) or dissolved in water (aqueous)

A & **B** are incorrect as	potassium bromide can't conduct electricity when it is solid. The ions are in a fixed position in the giant ionic lattice and there are no mobile charge carriers
D is incorrect as	when potassium bromide is **molten and aqueous**, the solid ionic lattice breaks down and the ions are now free to move as mobile charge carriers and can carry the electric charge through potassium bromide

8

The correct answer is **D** because:

- Ionic character is determined by the relative difference in electronegativity values between the two elements
- The greater the difference in electronegativity between the elements, the more likely the bonding is to be ionic
- Ca and O are furthest apart in electronegativity according to their positions in the periodic table

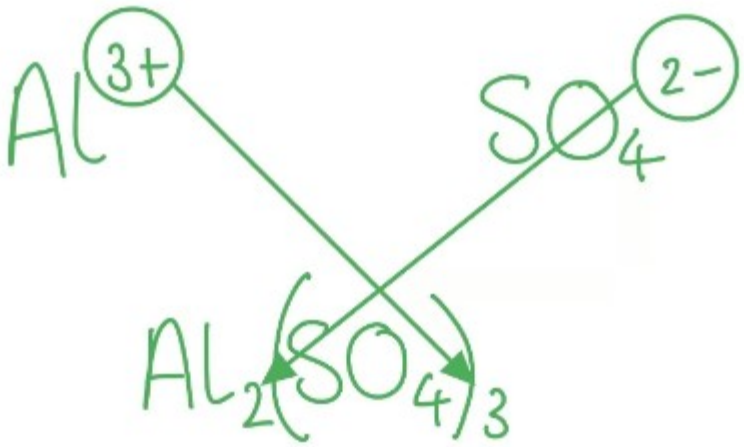


- Electronegativity increases across a period and decreases down a group

9

The correct answer is **C** because:

- Aluminium is an ionic compound
- Aluminium forms a 3+ ion (Al^{3+})
- Sulfate is a 2– ion (SO_4^{2-})
- Therefore the formula must be
  - $Al_2(SO_4)_3$
- You can use the 'swap and drop' method of working out formulas for ionic compounds:



- Finally, don't forget to include the brackets as otherwise the formula would read as though it contains 43 oxygen atoms, Al_2SO_{43} instead of $Al_2(SO_4)_3$

A, **B** & **D** are incorrect as	these do not contain the correct numbers of atoms of each element

10

The correct answer is **B** because:

- The A/atom has 3 electrons (represented by the crosses)
- Each I atom has 7 electrons, 3 x 7 = 21 (represented by dots)
- 21 + 3 = 24 electrons in total

A, **C** & **D** are incorrect as	these are not the correct numbers of electrons for aluminium iodide, AlI_3