1. **State the shape of the electron distribution around the oxygen atom in the water molecule and state the shape of the molecule**
2. **State and explain the value of the HOH bond angle**
3. (i) tetrahedral (*accept correct 3-D diagram*)  
   bent/V-shape/angular (*accept suitable diagram*)
4. (ii) 105° (*accept 103 – 106*°)  
   lone pairs **repel** each other more than bonding pairs

**Explain why the bonds in silicon tetrachloride, SiCl4, are polar, but the molecule is not**

bonds are polar as Cl more electronegative than Si

molecule is symmetrical, hence polar effects cancel out

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

1. **i) Identify which of the structures (A, B, C) correspond to iodine, sodium, sodium oxide**

**ii) State the type of bonding in each structure**

1. **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.**

**ii) Explain the high volatility of iodine compared to sodium and sodium iodide.**

(a) (i) A – sodium iodide, B – sodium, C – iodine (*three correct* ***[1]***)

Accept correct formulas.

(ii) A – ionic bonding  
B – metallic bonding  
C – van der Waals’ forces (and covalent bonding)

(b) (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

(ii) forces between I2 molecules are weak  
ionic/metallic bonding strong(er)

1. **Draw Lewis structures for CO2 and H2S showing all valence electrons**
2. **State the shape of each molecule and explain your answer in terms of VSEPR theory**
   1. **CO2:**
   2. **H2S**
3. **Explain and state whether each molecule is polar or non-polar.**



(ii) CO2 is linear;  
two charge centres or bonds and no lone pairs (around C);  
H2S is bent/v-shaped/angular;  
two bond pairs, two lone pairs (around S)

(iii) CO2 is non-polar, H2S is polar  
bond polarities cancel CO2 but not in H2S

**Identify the strongest type of intermolecular force in all of the compounds:**

* 1. **CH3Cl**
  2. **CH4**
  3. **CH3OH**

CH3Cl – dipole-dipole attractions  
CH4 – van der Waals’/dispersion/London forces  
CH3OH – hydrogen bond

**Draw a Lewis structure of a water molecule, name the shape of the molecule and state and explain why the bond angle is less than the bond angle in a tetrahedral molecule such as methane.**

 bent/V shaped/angular

104.5;

Accept answers in range 104 to 106.

repulsion of the two non-bonding pairs of electrons forces bond angle  
to be smaller/non-bonding pairs repel more than bonding pairs

**(i) Outline the principles of the valence shell electron pair repulsion (VSEPR) theory.**

**(ii) Use the VSEPR theory to deduce the shape of H3O+ and C2H4. For each species, draw the Lewis structure, name the shape, and state the value of the bond angle(s).**

**(iii) Predict and explain whether each species is polar.**

**(iv) Using Table 7 of the Data Booklet, predict and explain which of the bonds O-H, O-N or N-H would be most polar.**

(i) 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

*Any one of the following:*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/ max

(ii)

|  |  |  |  |
| --- | --- | --- | --- |
| **Species** | **Lewis (electron-dot) structure** | **Shape** | **Bond angle(s)** |
| H3O+ |  | Trigonal/triangular pyramidal; | Allow values in the range 106° to 109.5°; |
| C2H4 |  | Trigonal/triangular planar; | Allow values of approximately 120°; |

(iii) H3O+: is polar and explanation either using a diagram or in words,  
involving the net dipole moment;

e.g. the three individual O-H bond dipole moments add as vectors to give a net dipole moment.

C2H4: is non-polar and explanation either using a diagram or in words,  
involving no net dipole moment

e.g. the vector sum of the individual bond dipole moments is zero.

For simple answers such as bond polarities do not cancel for H3O+ and do cancel for C2H4, Award **[1]**, only for the last two marking points.

(iv) O-H is most polar;  
O-H has greatest difference between electronegativities/calculation  
showing values of 1.4, 0.5 and 0.9 respectively

**Diamond, graphite and C60 fullerene are three allotropes of carbon.**

**(i) Describe the structure of each allotrope.**

**(ii) Compare the bonding in diamond and graphite.**

(i) 3

|  |  |
| --- | --- |
| **Allotrope** | **Structure** |
| **Diamond** | 3D array/network involving tetrahedral carbons/each carbon atom joined to four others; |
| **Graphite** | layer structure involving trigonal (triangular) planar carbons/with each carbon atom joined to three others/with hexagonal (six-membered) rings of carbon atoms; |
| **C60 fullerene** | truncated icosahedrons; *Accept carbon atoms form a ‘ball’ with 32 faces, of which 12 are pentagons and 20 are hexagons, exactly like a soccer ball. Do not accept soccer ball alone*. |

(ii) Diamond: covalent bonds (only)  
Graphite: covalent bonds and the separated layers held together by  
(weak) London/van der Waals’/dispersion forces

**State two physical properties associated with metals and explain them at the atomic level.**

*Electrical conductivity:*Bonding electrons are delocalized  
Current flow occurs without displacement of atoms within the metal/  
able to flow within the metal

*Malleability:*Can be hammered into thin sheets  
atoms capable of slipping with respect to one another