**IB Chemistry – SL**

**Topic 4 Questions**

**1.** What is the formula for the compound formed by calcium and nitrogen?

A. CaN

B. Ca2N

C. Ca2N3

D. Ca3N2

(Total 1 mark)

**2.** Element *X* is in group 2, and element *Y* in group 7, of the periodic table. Which ions will be present in the compound formed when *X* and *Y* react together?

A. *X*+ and *Y*–

B. *X* 2+and *Y*–

C. *X*+ and *Y*2–

D. *X*2–and *Y*+

(Total 1 mark)

**3.** Based on electronegativity values, which bond is the most polar?

A. B―C

B. C―O

C. N―O

D. O―F

(Total 1 mark)

**4.** What is the Lewis (electron dot) structure for sulfur dioxide?

A. 

B. 

C. 

D. 

(Total 1 mark)

**5.** Which substance is most soluble in water (in mol dm–3) at 298 K?

A. CH3CH3

B. CH3OCH3

C. CH3CH2OH

D. CH3CH2CH2CH2OH

(Total 1 mark)

**6.** According to VSEPR theory, repulsion between electron pairs in a valence shell decreases in the order

A. lone pair-lone pair > lone pair-bond pair > bond pair-bond pair.

B. bond pair-bond pair > lone pair-bond pair > lone pair-lone pair.

C. lone pair-lone pair > bond pair-bond pair > bond pair-lone pair.

D. bond pair-bond pair > lone pair-lone pair > lone pair-bond pair.

(Total 1 mark)

**7.** Which molecule is linear?

A. SO2

B. CO2

C. H2S

D. Cl2O

(Total 1 mark)

**8.** Why is the boiling point of PH3 lower than that of NH3?

A. PH3 is non-polar whereas NH3 is polar.

B. PH3 is not hydrogen bonded whereas NH3 is hydrogen bonded.

C. London forces are weaker in PH3 than in NH3.

D. The molar mass of PH3 is greater than that of NH3.

(Total 1 mark)

**9.** Which molecule is non-polar?

A. H2CO

B. SO3

C. NF3

D. CHCl3

(Total 1 mark)

**10.** What happens when sodium and oxygen combine together?

A. Each sodium atom gains one electron.

B. Each sodium atom loses one electron.

C. Each oxygen atom gains one electron.

D. Each oxygen atom loses one electron.

(Total 1 mark)

**11.** Which statement is correct about **two** elements whose atoms form a covalent bond with each other?

A. The elements are metals.

B. The elements are non-metals.

C. The elements have very low electronegativity values.

D. The elements have very different electronegativity values.

(Total 1 mark)

**12.** Which substance has the lowest electrical conductivity?

A. Cu(s)

B. Hg(l)

C. H2(g)

D. LiOH(aq)

(Total 1 mark)

**13.** When the following bond types are listed in decreasing order of strength (strongest first), what is the correct order?

A. covalent  hydrogen  London

B. covalent  London  hydrogen

C. hydrogen  covalent  London

D. London  hydrogen  covalent

(Total 1 mark)

**14.** Which statement is true for most ionic compounds?

A. They contain elements of similar electronegativity.

B. They conduct electricity in the solid state.

C. They are coloured.

D. They have high melting and boiling points.

(Total 1 mark)

**15.** What is the valence shell electron pair repulsion (VSEPR) theory used to predict?

A. The energy levels in an atom

B. The shapes of molecules and ions

C. The electronegativities of elements

D. The type of bonding in compounds

(Total 1 mark)

**16.** Which fluoride is the most ionic?

A. NaF

B. CsF

C. MgF2

D. BaF2

(Total 1 mark)

**17.** Which substance is most similar in shape to NH3?

A. GaI3

B. BF3

C. FeCl3

D. PBr3

(Total 1 mark)

**18.** Which statement is a correct description of electron loss in this reaction?

2Al + 3S  Al2S3

A. Each aluminium atom loses two electrons.

B. Each aluminium atom loses three electrons.

C. Each sulfur atom loses two electrons.

D. Each sulfur atom loses three electrons.

(Total 1 mark)

**19.** Which molecule has the smallest bond angle?

A. CO2

B. NH3

C. CH4

D. C2H4

(Total 1 mark)

**20.** In which substance is hydrogen bonding present?

A. CH4

B. CH2F2

C. CH3CHO

D. CH3OH

(Total 1 mark)

**21.** Which is a correct description of metallic bonding?

A. Positively charged metal ions are attracted to negatively charged ions.

B. Negatively charged metal ions are attracted to positively charged metal ions.

C. Positively charged metal ions are attracted to delocalized electrons.

D. Negatively charged metal ions are attracted to delocalized electrons.

(Total 1 mark)

**22.** What intermolecular forces are present in gaseous hydrogen?

A. Hydrogen bonds

B. Covalent bonds

C. Dipole-dipole attractions

D. London forces

(Total 1 mark)

**23.** Which molecule is polar?

A. CO2

B. PF3

C. CH4

D. BF3

(Total 1 mark)

**24.** What are responsible for the high electrical conductivity of metals?

A. Delocalized positive ions

B. Delocalized valence electrons

C. Delocalized atoms

D. Delocalized negative ions

(Total 1 mark)

**25.** Which compound has the least covalent character?

A. SiO2

B. Na2O

C. MgCl2

D. CsF

(Total 1 mark)

**26.** When C2H4, C2H2 and C2H6 are arranged in order of **increasing** C–C bond length, what is the correct order?

A. C2H6, C2H2, C2H4

B. C2H4, C2H2, C2H6

C. C2H2, C2H4, C2H6

D. C2H4, C2H6, C2H2

(Total 1 mark)

**27.** Which compound contains **both** ionic and covalent bonds?

A. MgCl2

B. HCl

C. H2CO

D. NH4Cl

(Total 1 mark)

**28.** When the species BF2+, BF3 and BF4– are arranged in order of **increasing** F−B−F bond angle, what is the correct order?

A. BF3, BF4–, BF2+

B. BF4–, BF3, BF2+

C. BF2+, BF4–, BF3

D. BF2+, BF3, BF4–

(Total 1 mark)

**29.** Which species has a trigonal planar shape?

A. CO32–

B. SO32–

C. NF3

D. PCl3

**30.** When C2H4, C2H2 and C2H6 are arranged in order of **increasing** C–C bond length, what is the correct order?

A. C2H6, C2H2, C2H4

B. C2H4, C2H2, C2H6

C. C2H2, C2H4, C2H6

D. C2H4, C2H6, C2H2

(Total 1 mark)

**31.** What is the formula for an ionic compound formed between an element, X, from group 2 and an element, Y, from group 6?

A. XY

B. X2Y

C. XY2

D. X2Y6

(Total 1 mark)

**32.** In the molecules N2H4, N2H2, and N2, the nitrogen atoms are linked by single, double and triple bonds, respectively. When these molecules are arranged in increasing order of the lengths of their nitrogen to nitrogen bonds (shortest bond first) which order is correct?

A. N2H4, N2, N2H2

B. N2H4, N2H2, N2

C. N2H2, N2, N2H4

D. N2, N2H2, N2H4

(Total 1 mark)

**33.** The compounds listed have very similar molar masses. Which has the strongest intermolecular forces?

A. CH3CHO

B. CH3CH2OH

C. CH3CH2F

D. CH3CH2CH3

(Total 1 mark)

**34.** What is the shape of the CO32– ion and the approximate O–C–O bond angle?

A. Linear, 180

B. Trigonal planar, 90

C. Trigonal planar, 120

D. Pyramidal, 109

(Total 1 mark)

**35.** Which combination of *H*vaporization and boiling point is the result of strong intermolecular forces?

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| --- | --- | --- |
|  | *H*vaporization | Boiling Point |
| A. | large | high |
| B. | large | low |
| C. | small | low |
| D. | small | high |

(Total 1 mark)

**36.** What is the formula of the compound formed when aluminium reacts with oxygen?

A. Al3O2

B. Al2O3

C. AlO2

D. AlO3

(Total 1 mark)

**37.** Which statement is true for compounds containing only covalent bonds?

A. They are held together by electrostatic forces of attraction between oppositely charged ions.

B. They are made up of metal elements only.

C. They are made up of a metal from the far left of the periodic table and a non-metal from the far right of the periodic table.

D. They are made up of non-metal elements only.

(Total 1 mark)

**38.** How many electrons are used in the carbon-carbon bond in C2H2?

A. 4

B. 6

C. 10

D. 12

(Total 1 mark)

**39.** Which compound has the highest boiling point?

A. CH3CH2CH3

B. CH3CH2OH

C. CH3OCH3

D. CH3CHO

(Total 1 mark)

**40.** What type of solid materials are typically hard, have high melting points and poor electrical conductivities?

I. Ionic  
II. Metallic  
III. Covalent-network

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

(Total 1 mark)

**41.** The boiling points of the hydrides of the group 6 elements are shown below.



(i) Explain the trend in boiling points from H2S to H2Te.

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(2)

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

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(2)

(Total 4 marks)

**42.** (i) State the shape of the electron distribution around the oxygen atom in the water molecule and state the shape of the molecule.

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(2)

(ii) State and explain the value of the HOH bond angle.

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(2)

(Total 4 marks)

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

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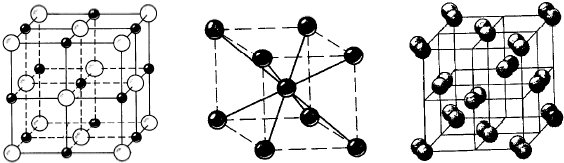
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(Total 2 marks)

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



**A B C**

(a) (i) Identify which of the structures (**A**, **B** and **C**) correspond to iodine, sodium and sodium iodide.

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(1)

(ii) State the type of bonding in each structure.

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(3)

(b) (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.

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(4)

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

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(2)

(Total 10 marks)

**45.** (i) Draw Lewis (electron dot) structures for CO2 and H2S showing all valence electrons.

(2)

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

CO2 .............................................................................................................................

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H2S .............................................................................................................................

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(4)

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

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(2)

(Total 8 marks)

**46.** Identify the strongest type of intermolecular force in each of the following compounds.

CH3Cl ...................................................................................................................................

CH4 .......................................................................................................................................

CH3OH .................................................................................................................................

(Total 3 marks)

**47.** (a) An important compound of nitrogen is ammonia, NH3. 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*.

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(2)

(ii) Draw a diagram to show hydrogen bonding between two molecules of NH3.  
The diagram should include any dipoles and/or lone pairs of electrons

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(3)

(iii) State the H–N–H bond angle in an ammonia molecule.

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(1)

(iv) Explain why the ammonia molecule is polar.

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(1)

(b) Ammonia reacts with hydrogen ions forming ammonium ions, NH4+.

(i) State the H–N–H bond angle in an ammonium ion.

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(1)

(ii) Explain why the H–N–H bond angle of NH3 is different from the H–N–H bond angle of NH4+; referring to both species in your answer.

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(3)

(Total 11 marks)

**48.** State the type of bonding in the compound SiCl4. Draw the Lewis structure for this compound.

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(Total 3 marks)

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

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(Total 3 marks)

**50.** (i) Use the VSEPR theory to predict and explain the shape and the bond angle of each of the molecules SCl2 and C2Cl2

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(6)

(ii) Deduce whether or not each molecule is polar, giving a reason for your answer.

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(3)

(Total 9 marks)

**51.** 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.

(Total 4 marks)

**52.** Predict and explain the order of the melting point for propanol, butane and propanone with reference to their intermolecular forces.

(Total 4 marks)

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

Describe the metallic bonding present in aluminium and explain why aluminium has a higher melting point than sodium.

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(Total 3 marks)

**54.** Draw the Lewis structure of NCl3. Predict, giving a reason, the Cl – N – Cl bond angle in NCl3.

(Total 3 marks)

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

NH2–, NH3, NH4+

(Total 5 marks)

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

(3)

(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).

(6)

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

(2)

(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.

(2)

(Total 13 marks)

**57.** Predict and explain which of the following compounds consist of molecules:  
NaCl, BF3, CaCl2, N2O, P4O6, FeS and CBr4.

(Total 2 marks)

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

(i) Describe the structure of each allotrope.

(3)

(ii) Compare the bonding in diamond and graphite.

(2)

(Total 5 marks)

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

(Total 4 marks)

**60.** (a) Draw the Lewis structure of methanoic acid, HCOOH.

(1)

(b) In methanoic acid, predict the bond angle around the

(2)

(i) carbon atom. .....................................................................................................

(ii) oxygen atom bonded to the hydrogen atom. ...................................................

(c) State and explain the relationship between the length and strength of the bonds between the carbon atom and the two oxygen atoms in methanoic acid.

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(3)

(Total 6 marks)

**IB Chemistry – SL**

**Topic 4 Answers**

**1.** D

[1]

**2.** B

[1]

**3.** B

[1]

**4.** D

[1]

**5.** C

[1]

**6.** A

[1]

**7.** B

[1]

**8.** B

[1]

**9.** B

[1]

**10.** B

[1]

**11.** B

[1]

**12.** C

[1]

**13.** A

[1]

**14.** D

[1]

**15.** B

[1]

**16.** B

[1]

**17.** D

[1]

**18.** B

[1]

**19.** B

[1]

**20.** D

[1]

**21.** C

[1]

**22.** D

[1]

**23.** B

[1]

**24.** B

[1]

**25.** D

[1]

**26.** C

[1]

**27.** D

[1]

**28.** B

[1]

**29.** A

[1]

**30.** C

[1]

**31.** A

[1]

**32.** D

[1]

**33.** B

[1]

**34.** C

[1]

**35.** A

[1]

**36.** B

[1]

**37.** D

[1]

**38.** B

[1]

**39.** B

[1]

**40.** B

[1]

**41.** (i) as molecules become larger/heavier/have higher *M*r values/  
number of electrons increases; London / dispersion forces increase; 2

(ii) hydrogen bonding **between molecules** in H2O; this bonding is stronger (than London forces); 2

Must be an implied comparison with (i)

[4]

**42.** (i) tetrahedral (*accept correct 3-D diagram*);  
bent/V-shape/angular (*accept suitable diagram*); 2

(ii) 105° (*accept 103 – 106*°);  
lone pairs **repel** each other more than bonding pairs; 2

Do not accept repulsion of atoms.

[4]

**43.** bonds are polar as Cl more electronegative than Si;

Allow “electronegativities are different”

molecule is symmetrical, hence polar effects cancel out/*OWTTE*; 2

[2]

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

Accept correct formulas.

(ii) A – ionic bonding;  
B – metallic bonding;  
C – London forces (and covalent bonding); 3

(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; 4

(ii) forces between I2 molecules are weak;  
ionic/metallic bonding strong(er); 2

[10]

**45.** (i) 2

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

(ii) CO2 is linear;  
two charge centers or bonds and no lone pairs (around C);  
H2S is bent/v-shaped/angular;  
two bond pairs, two lone pairs (around S); 4

(iii) CO2 is non-polar, H2S is polar;  
bond polarities cancel CO2 but not in H2S; 2

[8]

**46.** CH3Cl – dipole-dipole attractions;  
CH4 – London/dispersion/London forces;  
CH3OH – hydrogen bond; 3

[3]

**47.** (a) (i) (relative) measure of an atom’s attraction for electrons; in a bond; 2

(ii)



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

(iii) 107°; 1

Accept answer in range 107 to 109° .

(iv) molecule is asymmetrical/OWTTE; 1

(b) (i) 109.5°; 1

(ii) NH4+ has four bonding pairs   
(around central atom so is a regular tetrahedron);  
NH3 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.

[11]

**48.** Si—Cl bonds are covalent; 3



Accept lines for electron pairs.

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

[3]

**49.** find number of electron pairs/charge centers in (valence shell of) central atom;  
electron pairs/charge centers (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.

[3]

**50.** (i) SCl2 two bonding pairs, two non-bonding pairs;   
angular/bent/non-linear/V-shaped;  
*Both these marks can be scored from a diagram*.  
90° < angle < 107°;

C2Cl2 two charge centers around each C;  
linear;

Both these marks can be scored from a diagram.

angle = 180°; 6

(ii) SCl2 is polar;  
C2Cl2 is non-polar; 3  
No net dipole movement for C2Cl2 but angular SCl2 has a   
resultant dipole / *OWTTE*;

Mark can be scored from a diagram.

Allow ECF based on the answers given to (i).

[9]

**51.**



Allow a combination of dots, crosses or lines.

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; 4

[4]

**52.** butane < propanone < propanol;

butane has London forces;

Accept vdW, dispersion or London forces or attractions between temporary dipoles.

propanone has dipole-dipole attractions;

propanol has (the stronger) H-bonding; 4

[4]

**53.** delocalized electrons;  
(attracted) to positive ions;  
more delocalized/mobile/outer shell electrons/higher ionic charge; 3

[3]

**54.**



All electrons must be shown.

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

bond angle: 107109

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.

[3]

**55.** NH4+ > NH3 > NH2–;

NH4+ has four bonded electron pairs (and no lone electron pairs);

NH3 has three bonded electron pairs and one electron lone pair;

NH2– 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*; 5

Do not accept repulsion between atoms.

[5]

**56.** (i) Find number of electron pairs/charge centers in (valence shell of)  
central atom;  
electron pairs/charge centers (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/*OWTTE*; 3 max

Do not accept repulsion between bonds or atoms.

(ii) 6

|  |  |  |  |
| --- | --- | --- | --- |
| **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°; |

Accept crosses and dots for electrons in Lewis structures also.  
As the Lewis structures were asked for, and not 3D representations, do not penalize incorrectly drawn geometries.  
Do not accept structure of hydronium cation without lone pair on oxygen.  
No penalty for missing charge.

(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; 2

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; 2

[13]

**57.** BF3, N2O, P4O6 and CBr4;  
Non-metals only/small difference in electronegativity values of the elements; 2

[2]

**58.** (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/London/dispersion forces; 2

[5]

**59.** *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; 4

[4]

**60.** (a)

 1

No mark without lone electron pairs.

Correct shape not necessary.  
Do not award mark if dots/crosses and bond lines are shown.  
Accept lone pairs represented as straight lines.

(b) O − C − O = 120°/H − C − O = 120°;  
C − O − H = 109°/<109°; 2

No mark for 109.5°  
Accept answer in range 100–109°

(c) length: C = O < C − O;  
strength: C = O > C – O;  
greater number of electrons between nuclei pull atoms together and require greater energy to break;

Or

double bonds are shorter/single bonds are longer;  
double bonds are stronger/single bonds are weaker; 3

Accept stronger attraction between nuclei and (bonding) electrons.

[6]