Paper 1 SL

1. 2015 May TZ1 Q9 [4.2 VESPR]

9. What describes the structure of silicon and silicon dioxide?

	Silicon		Silicon Dioxide	
	Shape	**Si–Si bonds per silicon atom**	**Shape**	**Si–O bonds per silicon atom**
A.	planar	4	planar	4
B.	linear	2	linear	2
C.	tetrahedral	4	linear	2
D.	tetrahedral	4	tetrahedral	4

2. 2014 May TZ1 Q10 [4.2]

10. Which combination of length and strength of the carbon–to–carbon bonds in C_2H_2 and C_2H_4 is correct?

	Bond length	**Bond strength**
A.	$C_2H_2 > C_2H_4$	$C_2H_2 < C_2H_4$
B.	$C_2H_2 > C_2H_4$	$C_2H_2 > C_2H_4$
C.	$C_2H_2 < C_2H_4$	$C_2H_2 < C_2H_4$
D.	$C_2H_2 < C_2H_4$	$C_2H_2 > C_2H_4$

3. 2014 May TZ1 Q13 [4.5]

13. Which particles are present in the lattice of a metal?

A. Negative ions

B. Positive and negative ions

C. Positive ions

D. Molecules

4. 2013 May TZ2 Q13 [4.3]

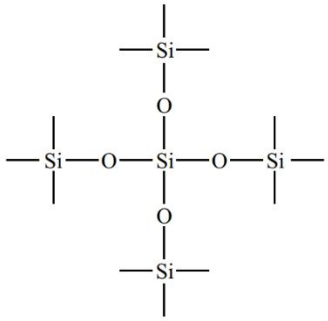
13. Which statements about the structure and bonding of silicon dioxide are correct?

	Structure	**Bonding**
A.	Silicon dioxide forms a giant covalent network.	Each oxygen atom is covalently bonded to two silicon atoms.
B.	Silicon dioxide molecules are V-shaped or bent.	Each silicon atom is covalently bonded to two oxygen atoms.
C.	Silicon dioxide molecules are linear.	A double covalent bond exists between silicon and oxygen atoms.
D.	Silicon dioxide forms a giant covalent network.	Each oxygen atom is covalently bonded to four silicon atoms.

5. 2014 May TZ2 Q13 [4.3]

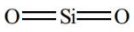
13. Which diagram represents the bonding in SiO_2?

A.

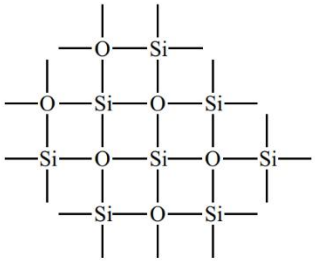


B.

C.



D.



6. 2012 Nov Q12 [4.3]

12. Diamond, C_{60} fullerene and graphite are allotropes of carbon. Which statements are correct about these allotropes?

I. In diamond each carbon is held in a tetrahedral arrangement.

II. In C_{60} fullerene each carbon is held in a trigonal arrangement.

III. In graphite each carbon is held in a tetrahedral arrangement.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

7. 2013 Nov Q11 [4.1]

11. Which compounds have an ionic lattice structure in the solid state?

I. Silicon dioxide

II. Sodium fluoride

III. Ammonium nitrate

A. I and II only

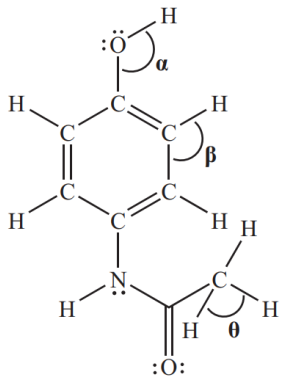
B. I and III only

C. II and III only

D. I, II and III

8. 2012 May TZ2 Q12 [4.3]

12. The Lewis (electron dot) structure of paracetamol (acetaminophen) is:



What are the approximate values of the bond angles?

	α	β	θ
A.	104.5°	120°	109.5°
B.	109.5°	109.5°	109.5°
C.	120°	120°	90°
D.	104.5°	120°	90°

9. 2011 May TZ2 Q8 [4.4]

8. Which change explains why the boiling points of the halogens increase as their molecular masses increase?

A. The intermolecular attraction due to temporarily induced dipoles increases.

B. The gravitational attraction between molecules increases.

C. The polarity of the bond within the molecule increases.

D. The strength of the bond within the molecule increases.

10. 2014 May TZ1 Q12 [4.4]

What is the correct order of **increasing** boiling point?

A. $C_2H_6 < HCHO < CH_3OH$

B. $HCHO < C_2H_6 < CH_3OH$

C. $CH_3OH < HCHO < C_2H_6$

D. $C_2H_6 < CH_3OH < HCHO$

11. 2009 May TZ2 Q10 [4.1 and 4.3]

Which statement best describes the **intramolecular** bonding in HCN(l)?

A. Electrostatic attractions between H^+ and CN^- ions

B. Only van der Waals' forces

C. Van der Waals' forces and hydrogen bonding

D. Electrostatic attractions between pairs of electrons and positively charged nuclei

12. 2017 Nov Q11 [4.4]

Which of the following series shows increasing hydrogen bonding with water?

A. Propane < propanal < propanol < propanoic acid

B. Propane < propanol < propanal < propanoic acid

C. Propanal < propane < propanoic acid < propanol

D. Propanoic acid < propanol < propanal < propane

13. 2014 May TZ1 Q13 [4.5]

Which particles are present in the lattice of a metal?

A. Negative ions

B. Positive and negative ions

C. Positive ions

D. Molecules

14. 2016 May Q12 [4.4]

Which of the following are van der Waals' forces?

I. Dipole-dipole forces
II. Hydrogen bonds
III. London (dispersion) forces

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

15. 2016 May Q11 [4.3]

Which compound has resonance structures?

A. C_6H_{12}

B. CH_3CHO

C. NaBr

D. Na_2CO_3

Paper 2

(1) 2015 May TZ2 Q6

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

a.ii. Predict the shape of the chloromethane molecule and the H–C–H bond angle. [2]

Shape:

Bond angle:

a.iii. Explain why chloromethane is a polar molecule. [2]

a.iv. Methanol has a lower molar mass than chloromethane. Explain why the boiling point of methanol is higher than that of chloromethane. [2]

b.i. State the equation for the reaction between potassium and chlorine. [1]

b.ii. Outline the nature of the metallic bonding present in potassium. [1]

b.iii. Describe the covalent bond present in the chlorine molecule and how it is formed. [2]

b.iv. Describe the ionic bonding present in potassium chloride and how the ions are formed. [2]

(2) 2013 May TZ2 Q5

Ionic bonding and covalent bonding are two types of bonding.

Consider the molecules sulfur difluoride, SF_2, boron trifluoride, BF_3, and phosphorus trichloride, PCl_3.

a.i. Ionic bonding occurs in sodium chloride. Describe what is meant by the term *ionic bonding*. [1]

a.ii. Sodium chloride has a lattice structure. Describe the lattice structure of sodium chloride including a suitable representative three-dimensional diagram. On the diagram, label each ion and distinguish between the different types of ions present using different sized spheres. [4]

a.iii. Ammonium phosphate is also an ionic compound, used in the manufacture of fertilizers. State the chemical formula of ammonium phosphate. [1]

b.i. Deduce the Lewis (electron dot) structure and predict the shape of each molecule, using the valence shell electron pair repulsion theory (VSEPR). [6]

	SF_2	BF_3	PCl_3
Lewis (electron dot) structure			
Shape	.....	.....	.....

b.ii.State and explain the F–S–F bond angle in SF_2. [3]

b.iiiDeduce whether each of the three molecules is polar or non-polar, giving your reason in each case. [3]

SF_2:

BF_3:

PCl_3:

c. Using electronegativity values from Table 7 of the Data Booklet, state and explain which of the following compounds, IBr, $BaCl_2$, CsI and HBr are ionic and which compounds are covalent. [2]

IBr:

$BaCl_2$:

CsI:

HBr:

(3) 2010 Nov Q3

Iron has three main naturally occurring isotopes which can be investigated using a mass spectrometer.

(a) The first stage in the operation of the mass spectrometer is vaporization. The iron is then ionized.

(i) Explain why the iron is ionized. *[2]*

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(ii) Explain why a very low pressure is maintained inside the mass spectrometer. *[1]*

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(b) A sample of iron has the following isotopic composition by mass.

Isotope	^{54}Fe	^{56}Fe	^{57}Fe
Relative abundance / %	5.95	91.88	2.17

Calculate the relative atomic mass of iron based on this data, giving your answer to **two decimal places.** *[2]*

(c) Calculate the number of electrons in the ion $^{56}Fe^{2+}$. *[1]*

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

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(4) 2010 Nov Q4

Ethene, C_2H_4, and hydrazine, N_2H_4, are hydrides of adjacent elements in the periodic table.

(a) (i) Draw Lewis (electron dot) structures for C_2H_4 and N_2H_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]*

(5) 2011 May TZ1 Q7

Carbon and silicon belong to the same group of the periodic table.

Both silicon and carbon form oxides.

b. State the period numbers of both carbon and silicon. [1]

c. Describe and compare **three** features of the structure and bonding in the three allotropes of carbon: diamond, graphite and C_{60} fullerene. [6]

d.i. Draw the Lewis structure of CO_2 and predict its shape and bond angle. [2]

d.ii. Describe the structure and bonding in SiO_2. [2]

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

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

f. Silicon has three stable isotopes, ^{28}Si, ^{29}Si and ^{30}Si. The heaviest isotope, ^{30}Si, has a percentage abundance of 3.1%. Calculate the percentage abundance of the lightest isotope to one decimal place. [2]

(6) 2012 May TZ1 Q5

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 Si_2H_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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(7) 2012 May TZ2 Q5

An organic compound, **X**, with a molar mass of approximately $88\ \mathrm{g\,mol^{-1}}$ contains 54.5% carbon, 36.3% oxygen and 9.2% hydrogen by mass.

a. (i) Distinguish between the terms *empirical formula* and *molecular formula*. [9]

Empirical formula:

Molecular formula:

(ii) Determine the empirical formula of **X**.

(iii) Determine the molecular formula of **X**.

(iv) **X** is a straight-chain carboxylic acid. Draw its structural formula.

(v) Draw the structural formula of an isomer of **X** which is an ester.

(vi) The carboxylic acid contains two different carbon-oxygen bonds. Identify which bond is stronger and which bond is longer.

Stronger bond:

Longer bond:

b. (i) State and explain which of propan-1-ol, $\mathrm{CH_3CH_2CH_2OH}$, and methoxyethane, $\mathrm{CH_3OCH_2CH_3}$, is more volatile. [5]

(ii) Propan-1-ol, $\mathrm{CH_3CH_2CH_2OH}$, and hexan-l-ol, $\mathrm{CH_3(CH_2)_4CH_2OH}$, are both alcohols. State and explain which compound is more soluble in water.

c. Graphite is used as a lubricant and is an electrical conductor. Diamond is hard and does not conduct electricity. Explain these statements in terms of the structure and bonding of these allotropes of carbon. [6]

Graphite:

Diamond:

(8) 2012 Nov Q4

Lithium and boron are elements in period 2 of the periodic table. Lithium occurs in group 1 (the alkali metals) and boron occurs in group 3. Isotopes exist for both elements.

Every element has its own unique line emission spectrum.

a. (i) Define the terms *atomic number*, *mass number* and *isotopes of an element*. [10]

Atomic number:

Mass number:

Isotopes of an element:

(ii) Distinguish between the terms *group* and *period*.

(iii) Deduce the electron arrangements of the lithium ion, $\mathrm{Li^+}$, and the boron atom, B.

$\mathrm{Li^+}$:

B:

(iv) Naturally occurring boron exists as two isotopes with mass numbers of 10 and 11. Calculate the percentage abundance of the lighter isotope, using this information and the relative atomic mass of boron in Table 5 of the Data Booklet.

v) Lithium exists as two isotopes with mass numbers of 6 and 7. Deduce the number of protons, electrons and neutrons for each isotope.

Mass number (*A*)	Number of protons	Number of electrons	Number of neutrons
6			
7			

b. (i) Distinguish between a *continuous spectrum* and a *line spectrum*. [6]

(ii) Draw a diagram to show the electron transitions between energy levels in a hydrogen atom that are responsible for the two series of lines in the ultraviolet and visible regions of the spectrum. Label your diagram to show **three** transitions for each series.

c. (i) Explain why metals are good conductors of electricity and why they are malleable. [4]

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

iii) Deduce the chemical formulas of lithium oxide and iron(II) oxide.

Lithium oxide:

Iron(II) oxide:

(9) 2013 Nov Q4

In December 2010, researchers in Sweden announced the synthesis of N,N–dinitronitramide, $N(NO_2)_3$. They speculated that this compound, more commonly called trinitramide, may have significant potential as an environmentally friendly rocket fuel oxidant.

a. Methanol reacts with trinitramide to form nitrogen, carbon dioxide and water. Deduce the coefficients required to balance the equation for this reaction. [1]

$$\_\_\ N(NO_2)_3(g) + \_\_\ CH_3OH(l) \rightarrow \_\_\ N_2(g) + \_\_\ CO_2(g) + \_\_\ H_2O(l)$$

c. Calculate the enthalpy change, in $kJ\ mol^{-1}$, when one mole of trinitramide decomposes to its elements, using bond enthalpy data from Table 10 of the Data Booklet. Assume that all the N–O bonds in this molecule have a bond enthalpy of $305\ kJ\ mol^{-1}$. [3]

d. Outline how the length of the N–N bond in trinitramide compares with the N–N bond in nitrogen gas, N_2. [2]

e. Deduce the N–N–N bond angle in trinitramide and explain your reasoning. [3]

f. Predict, with an explanation, the polarity of the trinitramide molecule. [2]

g.i. Methanol can also be burnt as a fuel. Describe an experiment that would allow the molar enthalpy change of combustion to be calculated from the results. [3]

g.ii. Explain how the results of this experiment could be used to calculate the molar enthalpy change of combustion of methanol. [3]

g.iii. Predict, with an explanation, how the result obtained would compare with the value in Table 12 of the Data Booklet. [2]