

3. Chemical bonding

3.4 Covalent bonding and coordinate bonding

Paper 2

Question Paper

1 Hydrocarbon molecules contain covalent bonds.

(a) Define covalent bond.

.....
 [1]

(b) A C=C bond in an alkene is made from a σ bond and a π bond.

(i) Identify the hybridisation of the carbon atoms in a C=C bond in an alkene.

..... [1]

(ii) Draw labelled diagrams to show, in terms of orbital overlap, how the σ and π bonds are made in a C=C bond.

σ bond

π bond

[2]

(c) In electrophilic reactions involving alkenes the π bond of C=C is broken.

(i) Suggest **one** difference between σ and π bonds that explains why the π bond is broken in electrophilic addition reactions involving alkenes.

.....
 [1]

(ii) Complete Fig. 5.1 to show the mechanism for the electrophilic addition of hydrogen bromide to 2-methylpropene to produce the major organic product.

Include charges, dipoles, lone pairs of electrons and curly arrows, as appropriate.



Fig. 5.1

[4]

- 2** (f) At very high temperatures, phosphorus can form P_2 molecules.

P_2 contains a triple bond, $P\equiv P$.

- (i) Describe the formation of the $P\equiv P$ bond in terms of orbital overlap.

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.....
.....
..... [2]

- (ii) The bond energy of $P\equiv P$ is 485kJ mol^{-1} . The bond energy of $N\equiv N$ is 944kJ mol^{-1} . Compare the reactivity of P_2 and N_2 . Explain your answer.

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.....
..... [1]

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- 3** Nitrogen molecules, $N_2(g)$, contain two atoms attracted to each other by a triple covalent bond.

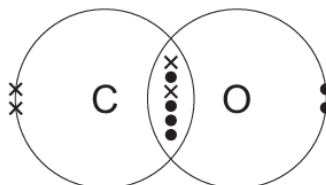
- (a) Describe how the triple covalent bond forms in a $N_2(g)$ molecule. Refer to orbital overlap and hybridisation in your answer.

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.....
.....
..... [3]

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4 Carbon monoxide gas, $\text{CO}(\text{g})$, and nitrogen gas, $\text{N}_2(\text{g})$, are both diatomic molecules.

(a) The diagram shows the arrangement of outer electrons in a molecule of $\text{CO}(\text{g})$.



(i) State **one** similarity and **one** difference in the way the atoms in a carbon monoxide molecule are bonded together compared to the atoms in a nitrogen molecule.

.....

 [2]

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5 The strength of interaction between particles determines whether the substance is a solid, liquid or gas at room temperature.

(b) Carbon monoxide, CO , is a gas at room temperature and pressure. It contains a coordinate bond.

(i) Explain what is meant by *coordinate bond*.

.....
 [1]

(ii) Draw a 'dot-and-cross' diagram to show the arrangement of outer electrons in CO .

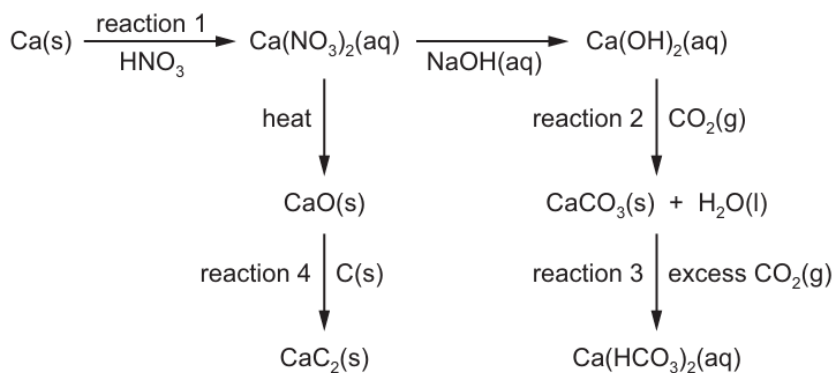
Show the electrons belonging to the C atom as x.

Show the electrons belonging to the O atom as •.

[2]

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- 6 The reaction scheme shows some reactions of calcium.



- (c) In reaction 4, calcium carbide, CaC_2 , is formed from CaO .

CaC_2 contains the C_2^{2-} anion. Each carbon in C_2^{2-} is sp hybridised.

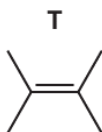
- (i) Describe how sp hybridised orbitals are formed.

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 [1]

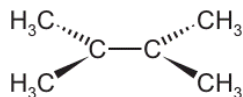
- (ii) Sketch a diagram to show how two sp hybrid orbitals can form a sigma (σ) bond.

[2]

- 7** Compound **T** is an isomer of C_6H_{12} .



- (c) Each carbon atom in **T** forms a sigma (σ) bond to at least one other carbon atom, as shown.



- (i) On the diagram, draw the orbitals that represent the pi (π) bond that is also present in **T**. [1]

- (ii) State the hybridisation of the two carbon atoms between which the pi (π) bond forms.

..... [1]

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- 8** The reducing agent $LiAlH_4$ can be synthesised by reacting aluminium chloride with lithium hydride, LiH .

- (a) (i) At $200^\circ C$, aluminium chloride exists as $Al_2Cl_6(g)$.

Draw the structure of $Al_2Cl_6(g)$, showing fully any coordinate (dative covalent) bonds in the molecule.

[2]

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