Chemistry 2.4 AS 91164

Demonstrate understanding of bonding, structure, properties and energy changes

WORKBOOK

Working to Excellence

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GZ Science Resources

Chemistry 2.4 AS 91164 Demonstrate understanding of bonding, structure, properties and energy changes

Writing Excellence answers to **Molecule shapes and bond angle** questions

Molecule shapes and bond angle QUESTION
Question: Carbon atoms can bond with different atoms to form many different compounds. The following table shows the Lewis structure for two molecules containing carbon as the central atom, CCl_4 and $COCl_2$. These molecules have different bond angles and shapes. Evaluate the Lewis structure of each molecule to determine why they have different bond angles and shapes. In your answer you should include: • The approximate bond angle in each molecule • The shape of each molecule • Factors that determine the shape and bond angle for each molecule. **Molecule** | CCl_4 | $COCl_2$ **Lewis structure** |  | 

ANSWER	
1. for first molecule (name) state number of regions of negative charge around the central atom (name central atom)	
2. state the **Valence shell electron pair repulsion (VSEPR) theory**	
3. state the base arrangement of negative regions and the bond angle they form	
4. state the number of **bonded** and **non-bonded** regions <u>AND</u> the final shape of the first molecule	
5. for second molecule (name) state number of regions of negative charge around the central atom (name central atom)	
6. state the **Valence shell electron pair repulsion (VSEPR) theory**	
7. state the base arrangement of negative regions and the bond angle they form	
8. state the number of **bonded** and **non-bonded** regions <u>AND</u> the final shape of the second molecule	
9. **compare** differences in bond angle linked to number of regions of negative charge.	

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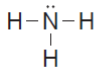
Writing Excellence answers to **Molecule Polarity** questions

Molecule Polarity QUESTION
Question: The Lewis structures for two molecules are shown. Ammonia, NH_3, is polar, and borane, BH_3, is non-polar. Justify this statement.

Molecule	 Ammonia	 Borane
Polarity of molecule	polar	non-polar

ANSWER	
1. For the first molecule (name) state the **types of bonds** present (name atoms) and state whether they are polar (form a dipole) or non-polar due to electronegativity.	
2. link **electronegativity** differences to sharing of electrons for your bond	
3. state the **shape** of your molecule and link to being symmetrical or not and result in dipoles cancelling (or not)	
4. link to final **polarity** of molecule	
5. For the second molecule (name) state the **types of bonds** present (name atoms) and state whether they are polar (form a dipole) or non-polar due to electronegativity.	
6. link **electronegativity** differences to sharing of electrons for your bond	
7. state the **shape** of your molecule and link to being symmetrical or not and result in dipoles cancelling (or not)	
8. link to final **polarity** of molecule	

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Writing Excellence answers to **Solids – Melting Point** questions

Solids – Melting Point QUESTION

Question: Explain why chlorine is a gas at room temperature, but copper chloride is a solid at room temperature.
In your answer, you should refer to the particles and the forces between the particles in **both** substances.
(you will need to fill in the chart below correctly as part of the question and use the terms in your answer)

Substance	Type of substance	Type of particle	Attractive forces between particles
$Cl_{2\ (s)}$ chlorine	Molecular	Molecules	Weak intermolecular forces
$CuCl_{2(s)}$ copper chloride	Ionic	Ion	Ionic bonds / electrostatic attraction

ANSWER

1. For the first substance (name) state the **type of solid** that it is	
2. describe the **structure** of this type of substance using the *terms* above in the table	
3. explain how the **bonding** relates to the energy required to break bonds of your substance	
4. link to the **observation** (state at room temperature) in your question for the first substance	
5. For the second substance (name) state the **type of solid** that it is	
6. describe the **structure** of this type of substance using the *terms* above in the table	
7. explain how the **bonding** relates to the energy required to break bonds of your substance	
8. link to the **observation** (state at room temperature) in your question for the first substance	

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Chemistry 2.4 AS 91164 Demonstrate understanding of bonding, structure, properties and energy changes

Writing Excellence answers to **Solids – Conductivity (Ductility)** questions

Solids – Conductivity (Ductility) QUESTION
Question: Using your knowledge of structure and bonding, explain why, although both graphite and copper are good **conductors** of electricity, copper is suitable for **electrical wires**, but graphite is not. (note <u>two properties</u> to discuss) (you will need to fill in the chart below <u>correctly</u> as part of the question and use the terms in your answer)

Substance	Type of substance	Type of particle	Attractive forces between particles
$C_{(s)}$ Graphite	Covalent network	Atom	Covalent (and weak intermolecular forces)
$Cu_{(s)}$ copper	metal	Atom / cations and electrons	Metallic bonds / electrostatic attraction

ANSWER	
1. For the first substance (name) state the **type of solid** that it is	
2. describe the **structure** of this type of substance using the *terms* above in the table	
3. explain how the **bonding** relates to the present of free moving charged particles to conduct electricity in your substance (property 1)	
4. link to the **observation** (conductivity) in your question for the first substance	
5. explain how the **bonding** relates to ductility in your substance (property 2)	
6. link to the **observation** (forming wires) in your question for the first substance	
7. For the second substance (name) state the **type of solid** that it is	
8. describe the **structure** of this type of substance using the *terms* above in the table	
9. explain how the **bonding** relates to the present of free moving charged particles to conduct electricity in your substance (property 1)	
10. link to the **observation** (conductivity) in your question for the second substance	
11. explain how the **bonding** relates to ductility in your substance (property 2)	
12. link to the **observation** (forming wires) in your question for the second substance	

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Writing Excellence answers to **Solids – Solubility** questions

Solids – Solubility QUESTION

Question: Justify this statement in terms of the particles, structure, and bonding of these solids. You may use diagrams in your justification.
Potassium chloride is soluble in water while Silicon dioxide and copper are insoluble in water
(you will need to fill in the chart below correctly as part of the question and use the terms in your answer)

Substance	Type of substance	Type of particle	Attractive forces between particles
$KCl_{(s)}$ potassium chloride	ionic	ion	Ionic bonds / electrostatic attraction
$SiO_{2(s)}$ silicon dioxide	Covalent network	atoms	covalent
Cu(s) copper	metal	atom	Metallic bonds / electrostatic attraction

ANSWER

1. For the first substance (name) state the **type of solid** that it is	
2. describe the **structure** of this type of substance using the *terms* above in the table	
3. explain how the **bonding** relates to the attraction between particles in your substance and water particles	
4. link to the **observation** (solubility) in your question for the first substance	
5. For the second substance (name) state the **type of solid** that it is	
6. describe the **structure** of this type of substance using the *terms* above in the table	
7. explain how the **bonding** relates to the attraction between particles in your substance and water particles	
8. link to the **observation** (solubility) in your question for the second substance	
9. For the third substance (name) state the **type of solid** that it is	
10. describe the **structure** of this type of substance using the *terms* above in the table	
11. explain how the **bonding** relates to the attraction between particles in your substance and water particles	
12. link to the **observation** (solubility) in your question for the third substance	

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Writing Excellence answers to **Endothermic and Exothermic** questions

Endothermic and Exothermic QUESTION
Question: Pentane, C_5H_{12}, is a liquid at room temperature. It evaporates at 36.1°C in an endothermic process. (i) Explain why the evaporation of pentane is an endothermic process. (ii) Draw, including labels, the energy diagram for the combustion of pentane, $C_5H_{12(l)}$. Pentane combustion: $C_5H_{12(l)} + 8O_{2(g)} \rightarrow 5CO_{2(g)} + 6H_2O_{(l)}$ $\Delta_r H^{\circ} = -3509$ kJ mol^{-1} Include in your diagram the reactants, products, and change in enthalpy.

ANSWER	
1. define an **endothermic** process	
2. For the substance (name) state the type of "solid" that it is	
3. link state change (liquid to gas) to breaking bonds requiring energy	
3. link state change to endothermic process	
4. draw **labelled diagram** including labelled axis's, reactants H_R, products H_P and change in enthalpy ΔH	

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Writing Excellence answers to **Thermochemical Calculations** questions

Thermochemical Calculations QUESTION	
Question: Hexane, C_6H_{14}, like pentane, will combust (burn) in sufficient oxygen to produce carbon dioxide gas and water. **Pentane combustion**: $C_5H_{12(l)} + 8O_{2(g)} \rightarrow 5CO_{2(g)} + 6H_2O_{(l)}$ $\Delta_r H^\circ = -3509$ kJ mol^{-1} **Hexane combustion:** $2C_6H_{14(l)} + 19O_{2(g)} \rightarrow 12CO_{2(g)} + 14H_2O_{(l)}$ $\Delta_r H^\circ = -8316$ kJ mol^{-1} Justify which alkane – pentane or hexane – will produce more heat energy when 125 g of each fuel is combusted in sufficient oxygen. $M(C_5H_{12})$ = 72.0 g mol^{-1} $M(C_6H_{14})$ = 86.0 g mol^{-1} (An equation and n=m/M are required for this type of thermochemical calculation)	
ANSWER	
1. Calculate the amount of **energy per mol** from the equation (divide $\Delta_r H^\circ$ by number mol of substance in equation) – substance 1	
2. calculate the **number of mols** of the known (K) n = m/M	
3. multiply amount of energy per mol (step 1) by number of mols calculated (step 2) to get **energy per mass** *Answer with units plus 3sgf*	
4. Calculate the amount of **energy per mol** from the equation (divide $\Delta_r H^\circ$ by number mol of substance in equation) – substance 2	
5. calculate the **number of mols** of the known (K) n = m/M	
6. multiply amount of energy per mol (step 4) by number of mols calculated (step 5) to get **energy per mass** *Answer with units plus 3sgf*	
7. compare both substances with **summary** statement	

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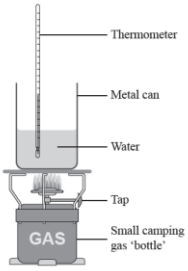
Writing Excellence answers to **Comparing Actual and Calculated enthalpy data** questions

Comparing Actual and Calculated enthalpy data QUESTION	
Question: The accepted enthalpy change for the combustion reaction of butane gas, $C_4H_{10(g)}$, is $\Delta r\ H = -5754$ kJ mol^{-1}. Explain why calculated enthalpy is different to the accepted value. In your answer, you should include at least TWO reasons.	
ANSWER	
1. state values for both calculated data (worked out from a previous question on experimental data) and accepted data *Units, sign and 3sgf*	
2. link results from experimental data to errors in experimental design	
3. explain error number 1.	
4. explain error number 2.	
5. explain error number 3.	
6. explain error number 4. (may need only 2 or 3 in answer)	
7. make summary statement linking that not energy released is transferred to heating the water	

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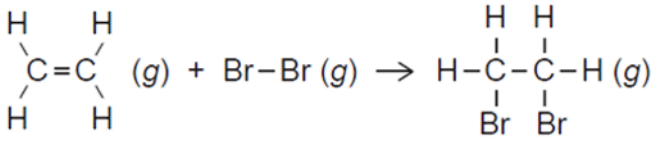
Writing Excellence answers to **Bond enthalpy** questions

Bond enthalpy QUESTION

Question: Ethene gas, $C_2H_{4\,(g)}$, reacts with bromine gas, $Br_{2(g)}$, as shown in the equation below.
Calculate the enthalpy change, $\Delta_r H°$, for the reaction between ethane and bromine gases, given the average bond enthalpies in the table below. Show your working and include appropriate units in your answers.



Bond	Average bond enthalpy/kJ mol^{-1}
Br–Br	193
C–C	346
C=C	614
C–Br	285
C–H	414

ANSWER

1. list types of bonds for reactants (bonds broken) and products (bonds formed) AND number of each, in a table. Watch for double or triple bonds as these are separate (Draw Lewis structures if not given)	Bonds broken (reactants)				Bonds formed (products)			
2. write bond type for each reactant (bonds broken) and product (bonds formed). Watch for double and triple bonds as they are different. Cross off on lewis diagram as you go	Bond type	number	enthalpy	Total enthalpy	Bond type	number	enthalpy	Total enthalpy
3. write the number of each bond type beside 4. multiply bond enthalpy by number of each bond								
5. total reactant bond enthalpy and total product enthalpy								
6. total enthalpy and calculate enthalpy change *(sign, units and 3sgf)* $\Delta_r H^o$ = ΣBond energies(bonds broken) – ΣBond energies(bonds formed)	Total Enthalpy (bonds broken)				Total enthalpy (bonds broken)			
	Total enthalpy =							
7. you may have to rearrange equation if enthalpy for a bond is required $\Delta_r H^o$ = ΣBond enthalpy (bonds broken) – ΣBond enthalpy (bonds formed)								

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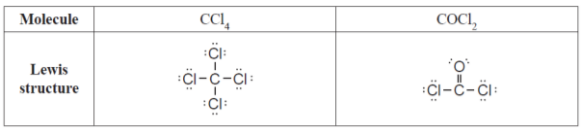
Writing Excellence answers to **Molecule shapes and bond angle** questions

Molecule shapes and bond angle QUESTION
Question: Carbon atoms can bond with different atoms to form many different compounds. The following table shows the Lewis structure for two molecules containing carbon as the central atom, CCl_4 and $COCl_2$. These molecules have different bond angles and shapes. Evaluate the Lewis structure of each molecule to determine why they have different bond angles and shapes. In your answer you should include: • The approximate bond angle in each molecule • The shape of each molecule • Factors that determine the shape and bond angle for each molecule. 

ANSWER	
1. for first molecule (name) state number of regions of negative charge around the central atom (name central atom)	In each CCl_4 molecule, there are four negative electron clouds / regions around the central C atom.
2. state the **Valence shell electron pair repulsion (VSEPR) theory**	These regions of negative charge repel each other as far away from each other as possible around the central C atom
3. state the base arrangement of negative regions and the bond angle they form	in a tetrahedral (base) arrangement, resulting in a 109.5° bond angle
4. state the number of **bonded** and **non-bonded** regions <u>AND</u> the final shape of the first molecule	All of these regions of electrons are bonding, without any non-bonding regions, so the final shape of the molecule is tetrahedral.
5. for second molecule (name) state number of regions of negative charge around the central atom (name central atom)	In each $COCl_2$ molecule, there are three negative electron clouds / regions around the central C atom.
6. state the **Valence shell electron pair repulsion (VSEPR) theory**	These regions of negative charge repel each other as far away from each other as possible around the central C atom
7. state the base arrangement of negative regions and the bond angle they form	in a triangular / trigonal planar (base) shape, resulting in a 120° bond angle.
8. state the number of **bonded** and **non-bonded** regions <u>AND</u> the final shape of the second molecule	All of these regions of electrons are bonding, without any non-bonding regions, so the final shape of the molecule is trigonal planar.
9. **compare** differences in bond angle linked to number of regions of negative charge.	Both molecules have <u>no</u> non-bonding pairs but because CCl_4 has 4 regions of negative charge around the central atom compared to the 3 regions that $COCl_2$ has, then CCl_4 has a smaller bond angle of 109.5° compared to the 120° bond angle of $COCl_2$

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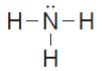
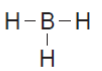
Writing Excellence answers to **Molecule Polarity** questions

Molecule Polarity QUESTION
Question: The Lewis structures for two molecules are shown. Ammonia, NH_3, is polar, and borane, BH_3, is non-polar. Justify this statement.

Molecule	 Ammonia	 Borane
Polarity of molecule	polar	non-polar

ANSWER	
1. For the first molecule (name) state the **types of bonds** present (name atoms) and state whether they are polar (form a dipole) or non-polar due to electronegativity.	Each N-H bond in NH_3 is polar / forms a dipole because the N and H atoms have different **electronegativities.**
2. link **electronegativity** differences to sharing of electrons for your bond	The electronegativity differences of the atoms means there is uneven sharing of the valence electrons (the electrons will spend more time around N than H causing N to be slightly negative and H to be slightly positive)
3. state the **shape** of your molecule and link to being symmetrical or not and result in dipoles cancelling (or not)	The shape of the molecule (due to the presence of one non-bonding electron pair) is trigonal pyramidal which is asymmetrical, so the dipoles / bond polarities do not cancel.
4. link to final **polarity** of molecule	The **resulting NH_3 molecule overall is polar.**
5. For the second molecule (name) state the **types of bonds** present (name atoms) and state whether they are polar (form a dipole) or non-polar due to electronegativity.	Each B-H bond in BH_3 is polar / forms a dipole because the B and H atoms have different **electronegativities.**
6. link **electronegativity** differences to sharing of electrons for your bond	The electronegativity differences of the atoms means there is uneven sharing of the valence electrons (the electrons will spend more time around B than H causing B to be slightly negative and H to be slightly positive)
7. state the **shape** of your molecule and link to being symmetrical or not and result in dipoles cancelling (or not)	The shape of the molecule is trigonal planar which is symmetrical, so the dipoles / bond polarities cancel.
8. link to final **polarity** of molecule	The **resulting BH_3 molecule overall is non-polar.**

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Writing Excellence answers to **Solids – Melting Point** questions

Solids – Melting Point QUESTION

Question: Explain why chlorine is a gas at room temperature, but copper chloride is a solid at room temperature.
In your answer, you should refer to the particles and the forces between the particles in **both** substances.
(you will need to fill in the chart below correctly as part of the question and use the terms in your answer)

Substance	Type of substance	Type of particle	Attractive forces between particles
$Cl_{2\ (s)}$ chlorine	Molecular	Molecules	Weak intermolecular forces
$CuCl_{2(s)}$ copper chloride	Ionic	Ion	Ionic bonds / electrostatic attraction

ANSWER

1. For the first substance (name) state the **type of solid** that it is	Chlorine is a molecular substance
2. describe the **structure** of this type of substance using the *terms* above in the table	composed of chlorine molecules held together by weak intermolecular forces
3. explain how the **bonding** relates to the energy required to break bonds of your substance	The weak intermolecular forces do not require much heat energy to break, so the boiling point is low (lower than room temperature);
4. link to the **observation** (state at room temperature) in your question for the first substance	therefore chlorine is a gas at room temperature.
5. For the second substance (name) state the **type of solid** that it is	Copper chloride is an ionic substance.
6. describe the **structure** of this type of substance using the *terms* above in the table	It is composed of a lattice of positive copper ions and negative chloride ions held together by electrostatic attraction (ionic bonds) between these positive and negative ions.
7. explain how the **bonding** relates to the energy required to break bonds of your substance	These are strong forces, therefore they require considerable energy to disrupt them and melt the copper chloride;
8. link to the **observation** (state at room temperature) in your question for the first substance	hence copper chloride is a solid at room temperature.

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Writing Excellence answers to **Solids – Conductivity (Ductility)** questions

Solids – Conductivity (Ductility) QUESTION

Question: Using your knowledge of structure and bonding, explain why, although both graphite and copper are good **conductors** of electricity, copper is suitable for **electrical wires**, but graphite is not. (note two properties to discuss)
(you will need to fill in the chart below correctly as part of the question and use the terms in your answer)

Substance	Type of substance	Type of particle	Attractive forces between particles
$C_{(s)}$ Graphite	Covalent network	Atom	Covalent (and weak intermolecular forces)
$Cu_{(s)}$ copper	metal	Atom / cations and electrons	Metallic bonds / electrostatic attraction

ANSWER

1. For the first substance (name) state the **type of solid** that it is	**Graphite** is a **covalent network** solid
2. describe the **structure** of this type of substance using the *terms* above in the table	composed of layers of C atoms covalently bonded to three other C atoms. The remaining valence electron is delocalised (ie free to move) between layers;
3. explain how the **bonding** relates to the present of free moving charged particles to conduct electricity in your substance (property 1)	The delocalised electrons are able to carry an electrical charge
4. link to the **observation** (conductivity) in your question for the first substance	Therefore graphite is **able to conduct** electricity
5. explain how the **bonding** relates to ductility in your substance (property 2)	In graphite, the attractive forces holding the layers together are very weak and are broken easily, so the layers easily slide over one another,
6. link to the **observation** (forming wires) in your question for the first substance	but the attraction is not strong enough to hold the layers together and allow it to be drawn into wires or although the layers can slide due to weak forces, if graphite was to be made into a wire the very strong covalent bonds within the layers would have to be broken. Graphite **cannot form wires.**
7. For the second substance (name) state the **type of solid** that it is	**Copper** is a **metallic** substance
8. describe the **structure** of this type of substance using the *terms* above in the table	composed of copper atoms packed together. Valence electrons are loosely held and are attracted to the nuclei of the neighbouring Cu atoms ;ie the bonding is non-directional.
9. explain how the **bonding** relates to the present of free moving charged particles to conduct electricity in your substance (property 1)	These delocalised valence electrons are free moving and can carry a charge
10. link to the **observation** (conductivity) in your question for the second substance	Therefore copper is **able to conduct** electricty
11. explain how the **bonding** relates to ductility in your substance (property 2)	In copper, the non-directional metallic bonding holds the layers together, allowing it to be stretched without breaking.
12. link to the **observation** (forming wires) in your question for the second substance	Therefore Copper metal is malleable and can **easily be drawn into wires** since, as it is stretched out,

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Writing Excellence answers to **Solids – Solubility** questions

Solids – Solubility QUESTION

Question: Justify this statement in terms of the particles, structure, and bonding of these solids. You may use diagrams in your justification.
Potassium chloride is soluble in water while Silicon dioxide and copper are insoluble in water
(you will need to fill in the chart below correctly as part of the question and use the terms in your answer)

Substance	Type of substance	Type of particle	Attractive forces between particles
$KCl_{(s)}$ potassium chloride	ionic	ion	Ionic bonds / electrostatic attraction
$SiO_{2(s)}$ silicon dioxide	Covalent network	atoms	covalent
Cu(s) copper	metal	atom	Metallic bonds / electrostatic attraction

ANSWER

1. For the first substance (name) state the **type of solid** that it is	$KCl_{(s)}$ potassium chloride is an ionic solid.
2. describe the **structure** of this type of substance using the *terms* above in the table	KCl is made up of positive K^+ ions, and negative Cl^- ions, ionically bonded in a 3D lattice.
3. explain how the **bonding** relates to the attraction between particles in your substance and water particles	When added to water, polar water molecules form electrostatic attractions with the K^+ and Cl^- ions. The partial negative charge, δ^-, on oxygen atoms in water are attracted to the K^+ ions and the partial positive, δ^+, charges on the H's in water are attracted to the Cl^- ions,
4. link to the **observation** (solubility) in your question for the first substance	causing KCl to dissolve in water, and **therefore be soluble**
5. For the second substance (name) state the **type of solid** that it is	$SiO_{2(s)}$ silicon dioxide is a covalent network solid.
6. describe the **structure** of this type of substance using the *terms* above in the table	$SiO_{2(s)}$ is made up of atoms covalently bonded together in a 3D lattice structure.
7. explain how the **bonding** relates to the attraction between particles in your substance and water particles	(Covalent bonds are strong), Polar water molecules are not strong / insufficiently attracted to the Si and O atoms,
8. link to the **observation** (solubility) in your question for the second substance	therefore **SiO_2 is insoluble** in water.
9. For the third substance (name) state the **type of solid** that it is	$Cu_{(s)}$ copper is a metallic solid.
10. describe the **structure** of this type of substance using the *terms* above in the table	$Cu_{(s)}$ is made up of an array of atoms (or ions) held together by non-directional forces between the positive nuclei of the atoms and the delocalised / free moving valence electrons.
11. explain how the **bonding** relates to the attraction between particles in your substance and water particles	There is no attraction between the copper atoms and the (polar) water molecules,
12. link to the **observation** (solubility) in your question for the third substance	therefore Cu is **insoluble in water**.

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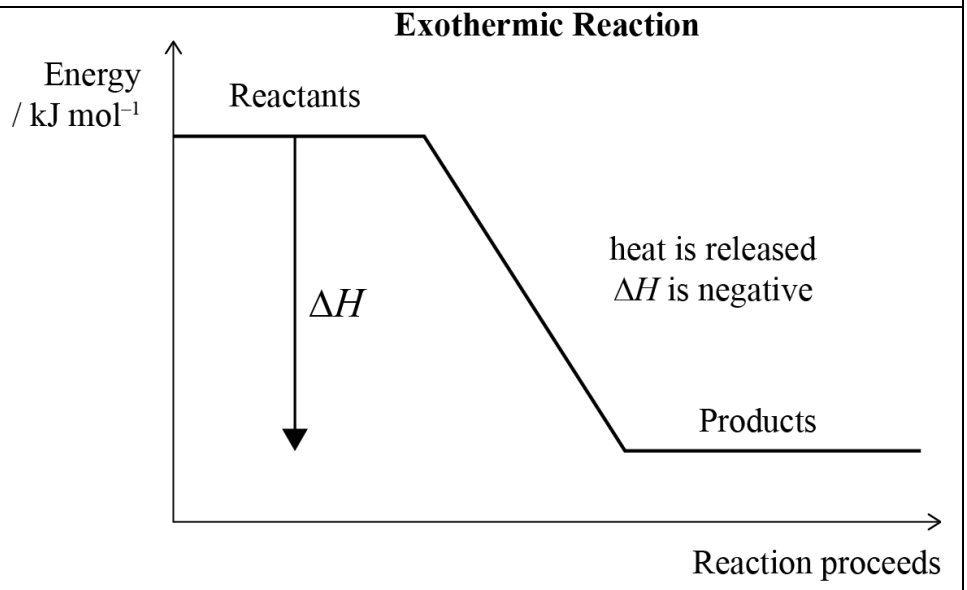
Chemistry 2.4 AS 91164 Demonstrate understanding of bonding, structure, properties and energy changes

Writing Excellence answers to **Endothermic and Exothermic** questions

Endothermic and Exothermic QUESTION
Question: Pentane, C_5H_{12}, is a liquid at room temperature. It evaporates at 36.1°C in an endothermic process. (i) Explain why the evaporation of pentane is an endothermic process. (ii) Draw, including labels, the energy diagram for the combustion of pentane, $C_5H_{12(l)}$. Pentane combustion: $C_5H_{12(l)} + 8O_{2(g)} \rightarrow 5CO_{2(g)} + 6H_2O_{(l)}$ $\Delta_r H^{\circ} = -3509$ kJ mol^{-1} Include in your diagram the reactants, products, and change in enthalpy.

ANSWER	
1. define an **endothermic** process	An Endothermic process is one where heat / energy has been absorbed and the enthalpy of the products is higher than the reactants
2. For the substance (name) state the type of "solid" that it is	Pentane is a molecular "solid" made up of molecules held together by weak intermolecular bonds.
3. link state change (liquid to gas) to breaking bonds requiring energy	Energy is required to change pentane from a liquid to a gas. The energy / heat is used to break weak intermolecular forces / bonds / attraction between pentane molecules. (not the strong covalent bonds between atoms in the molecule)
3. link state change to endothermic process	Because energy is needed to be absorbed by the pentane to break the bonds then this process of evapouration is endothermic.
4. draw **labelled diagram** including labelled axis's, reactants H_R, products H_P and change in enthalpy ΔH	

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Chemistry 2.4 AS 91164 Demonstrate understanding of bonding, structure, properties and energy changes

Writing Excellence answers to **Thermochemical Calculations** questions

Thermochemical Calculations QUESTION
Question: Hexane, C_6H_{14}, like pentane, will combust (burn) in sufficient oxygen to produce carbon dioxide gas and water. **Pentane combustion**: $C_5H_{12(l)} + 8O_{2(g)} \rightarrow 5CO_{2(g)} + 6H_2O_{(l)}$ $\Delta_r H^\circ = -3509$ kJ mol^{-1} **Hexane combustion:** $2C_6H_{14(l)} + 19O_{2(g)} \rightarrow 12CO_{2(g)} + 14H_2O_{(l)}$ $\Delta_r H^\circ = -8316$ kJ mol^{-1} Justify which alkane – pentane or hexane – will produce more heat energy when 125 g of each fuel is combusted in sufficient oxygen. $M(C_5H_{12})$ = 72.0 g mol^{-1} $M(C_6H_{14})$ = 86.0 g mol^{-1} (An equation and n=m/M are required for this type of thermochemical calculation)

ANSWER	
1. Calculate the amount of **energy per mol** from the equation (divide $\Delta_r H^\circ$ by number mol of substance in equation) – substance 1	1 mole of pentane releases 3509 kJ energy $\frac{1}{1} : \frac{3509}{1}$
2. calculate the **number of mols** of the known (K) n = m/M	*n* (pentane) = m / M *n* (pentane) = 125 g / 72.0 g mol^{-1} = 1.74 mol
3. multiply amount of energy per mol (step 1) by number of mols calculated (step 2) to get **energy per mass** *Answer with units plus 3sgf*	1.74 × 3509 = **6106 kJ energy** released.
4. Calculate the amount of **energy per mol** from the equation (divide $\Delta_r H^\circ$ by number mol of substance in equation) – substance 2	If 2 moles of hexane release 8316 kJ energy, then 1 mole of hexane releases 4158 kJ energy. $\frac{2}{2} : \frac{8316}{2}$
5. calculate the **number of mols** of the known (K) n = m/M	*n* (hexane) = m / M *n* (hexane) = 125 g / 86.0 g mol^{-1} = 1.45 mol
6. multiply amount of energy per mol (step 4) by number of mols calculated (step 5) to get **energy per mass** *Answer with units plus 3sgf*	1.45 × 4158 = **6029 kJ energy** released
7. compare both substances with **summary** statement	Pentane releases 6106 kJ of energy and Hexane releases 4158 kJ of energy, therefore **pentane releases more energy** (77.0 kJ) than hexane, per 125 g of fuel.

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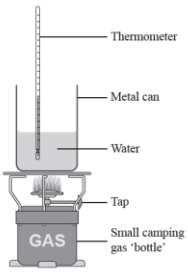
Chemistry 2.4 AS 91164 Demonstrate understanding of bonding, structure, properties and energy changes

Writing Excellence answers to **Comparing Actual and Calculated enthalpy data** questions

Comparing Actual and Calculated enthalpy data QUESTION
Question: The accepted enthalpy change for the combustion reaction of butane gas, $C_4H_{10(g)}$, is $\Delta r\ H = -5754$ kJ mol^{-1}. Explain why calculated enthalpy is different to the accepted value. In your answer, you should include at least TWO reasons. 

ANSWER	
1. state values for both calculated data (worked out from a previous question on experimental data) and accepted data *Units, sign and 3sgf*	The value for calculated data worked out from a previous question on experimental data for the combustion reaction of butane gas is **$\Delta_r H = -3370$ kJ mol^{-1}** The accepted enthalpy change for the combustion reaction of butane gas, $C_4H_{10(g)}$, is **$\Delta r\ H = -5754$ kJ mol^{-1}.**
2. link results from experimental data to errors in experimental design	The results from this experiment are less than the accepted results, due to errors in the experimental design. The errors could include:
3. explain error number 1.	Some energy is used to heat the metal can and the air surrounding the experiment / the experiment was not conducted in a closed system, therefore not the entire amount is heating the water
4. explain error number 2.	Incomplete combustion of butane, which releases less energy per mol of heat, to transfer to the water
5. explain error number 3.	Some butane may have escaped before being ignited and therefore not all of the fuel is combusted with the heat energy transferred
6. explain error number 4. (may need only 2 or 3 in answer)	Some energy was converted to light and sound OR The butane in the gas canister was impure OR Not carried out under standard conditions etc
7. make summary statement linking that not energy released is transferred to heating the water	Therefore, not all of the energy released by the combustion of butane was transferred to heating the water, and the experimental data was calculated to be less than the actual data (carried out under error free conditions)

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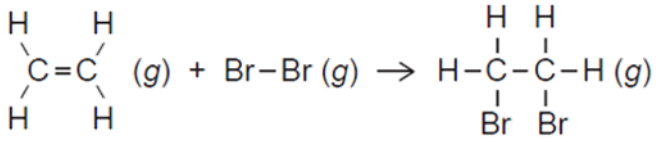
Chemistry 2.4 AS 91164 Demonstrate understanding of bonding, structure, properties and energy changes

Writing Excellence answers to **Bond enthalpy** questions

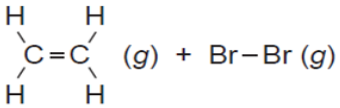
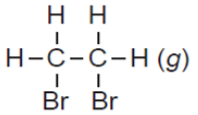
Bond enthalpy QUESTION

Question: Ethene gas, $C_2H_{4\,(g)}$, reacts with bromine gas, $Br_{2(g)}$, as shown in the equation below.
Calculate the enthalpy change, $\Delta_r H°$, for the reaction between ethane and bromine gases, given the average bond enthalpies in the table below. Show your working and include appropriate units in your answers.



Bond	Average bond enthalpy/kJ mol^{-1}
Br–Br	193
C–C	346
C=C	614
C–Br	285
C–H	414

ANSWER

1. list types of bonds for reactants (bonds broken) and products (bonds formed) AND number of each, in a table. Watch for double or triple bonds as these are separate (Draw Lewis structures if not given)	Bonds broken (reactants) 				Bonds formed (products) 			
2. write bond type for each reactant (bonds broken) and product (bonds formed). Watch for double and triple bonds as they are different. Cross off on lewis diagram as you go	Bond type	number	enthalpy	Total enthalpy	Bond type	number	enthalpy	Total enthalpy
3. write the number of each bond type beside 4. multiply bond enthalpy by number of each bond	C=C	1	614	614	C-C	1	346	346
	C-H	4	414	1656	C-H	4	414	1656
5. total reactant bond enthalpy and total product enthalpy	Br-Br	1	193	193	C-Br	2	285	570
6. total enthalpy and calculate enthalpy change *(sign, units and 3sgf)* $\Delta_r H^o$ = ΣBond energies(bonds broken) – ΣBond energies(bonds formed)	Total Enthalpy (bonds broken)			2463kJ	Total enthalpy (bonds broken)			2572kJ
	Total enthalpy = 2463 – 2572 = **-109kJ mol^{-1}**							
7. you may have to rearrange equation if enthalpy for a bond is required $\Delta_r H^o$ = ΣBond enthalpy (bonds broken) – ΣBond enthalpy (bonds formed)	Not needed							

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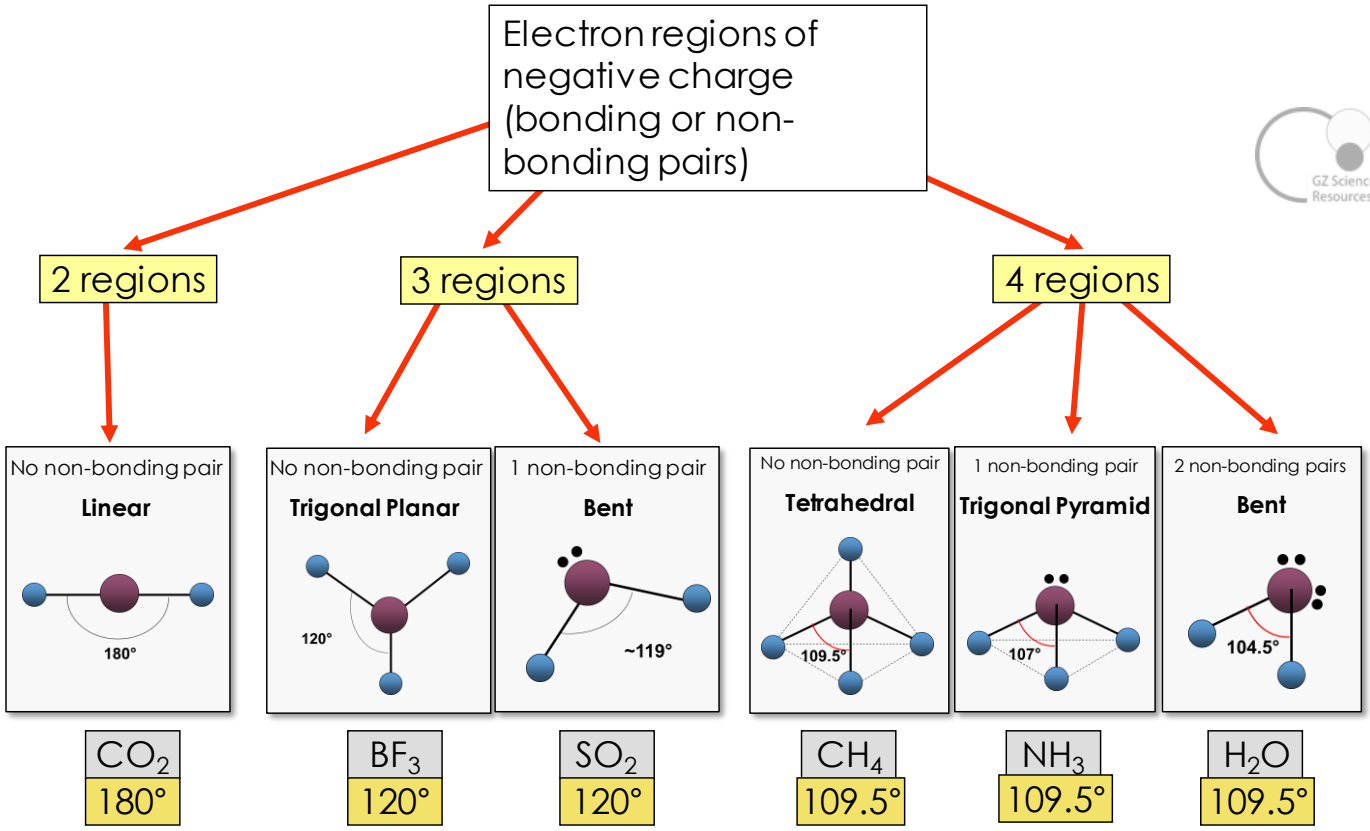
Solids Summary

Name of solid substance	Type of particle in solid	Attractive force broken when solid melts	Attractive force between particle – weak or strong (hardness)	Relative melting point	solubility	Electrical conductivity	Malleable
Molecular	molecules	Weak inter molecular	weak	low	Yes if polar No if non-polar	no	no
Metallic	atoms	Metallic bonding	strong	high	no	yes	yes
Ionic	ions	Electrostatic Ionic bonding	strong	high	yes	Only if molten or in solution	no
Covalent Network	atoms	Covalent bonding	strong	high	no	no	no

Determining Molecular Shapes



Non-metals forming molecules

I_2 S_2 HCl

Particles: molecules	Bonding: weak intermolecular

Molecules are held together by weak intermolecular bonding. Within the Molecules, the atoms are held together by strong covalent bonds.

Conductivity	Melting point	Solubility	Hardness
no	Low	No – non-polar Yes - polar	soft

Elements that are metals

Al Fe Cu

Particles: atoms	Bonding: metallic

Metal atoms are held together in a 3–D lattice by non-directional metallic bonding in which valence electrons are attracted to the nuclei of neighbouring atoms.

Conductivity	Melting point	Solubility	Hardness
yes	high	no	Yes but malleable

Ionic Solids

Non-metals and metals together forming a ionic compound

NaCl KI $CuSO_4$

Particles: ions	Bonding: electrostatic / ionic

Ions held together by strong directional electrostatic forces (ionic bonding) between +ve (cations) and –ve (anions) ions in a 3-dimensional lattice

Conductivity	Melting point	Solubility	Hardness
No–solid Yes-liquid or aqueous	Very high	yes	Hard but brittle

Covalent Network Solids

Carbon and silicon dioxide

C - graphite C - diamond SiO_2

Particles: atoms	Bonding: covalent

Diamond and SiO_2 are 3-dimensional covalent network structures where atoms are held together by strong covalent bonds in all planes. **Graphite** is a covalent network structure that is in 2 dimensional sheets. Between the layers are free moving valence electrons

Conductivity	Melting point	Solubility	Hardness
Yes - Graphite No - Diamond/SiO_2	Very high	no	Hard – diamond Soft -graphite