2

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91164

911640

NZQA

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Level 2 Chemistry, 2015

91164 Demonstrate understanding of bonding, structure, properties and energy changes

9.30 a.m. Monday 23 November 2015
Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of bonding, structure, properties and energy changes.	Demonstrate in-depth understanding of bonding, structure, properties and energy changes.	Demonstrate comprehensive understanding of bonding, structure, properties and energy changes.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

A periodic table is provided on the Resource Sheet L2–CHEMR.

If you need more room for any answer, use the extra space provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2 – 12 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Low Merit

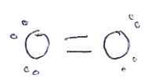
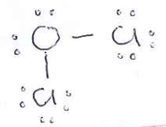
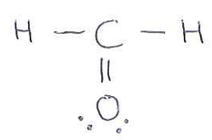
TOTAL 16

ASSESSOR'S USE ONLY

QUESTION ONE

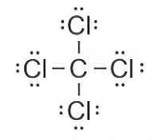
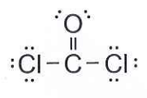
ASSESSOR'S USE ONLY

(a) Draw the Lewis structure (electron dot diagram) for each of the following molecules.

Molecule	O_2	OCl_2	CH_2O
Lewis structure			

(b) 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.

Molecule	CCl_4	$COCl_2$
Lewis structure		

Evaluate the Lewis structure of each molecule to determine why they have different bond angles and shapes.

In your answer, you should include:

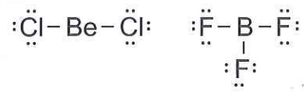
- the approximate bond angle in each molecule
- the shape of each molecule
- factors that determine the shape and bond angle for each molecule.

CCl_4 will be tetrahedral shape due to its 4 ~~bonded~~ electron densities. This will result in bond angles of 109° as the electrons will repel eachother.

$COCl_2$ will be trigonal planar shaped, due to it's 3 ~~bonded~~ electron & densities. This will result in bond angles of 120° as the 3 electron bond densities will repel eachother.

ASSESSOR'S USE ONLY

(c) $BeCl_2$ and BF_3 are unusual molecules because there are not enough electrons for the central atoms, Be and B, to have a full valence shell. Their Lewis structures are shown below.



Both molecules have the same polarity.

Circle the word that describes the polarity of these molecules.

polar **non-polar**

Justify your choice.

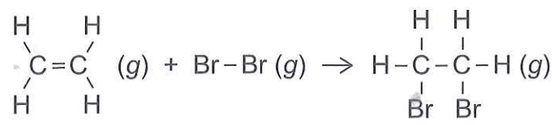
Both $BeCl_2$ and BF_3 are non-polar due to ~~there~~ their symmetrical polar bonds.

$BeCl_2$ is a linear molecule, so the polarity of each Cl-Be bond cancels out, creating a non-polar molecule.

BF_3 is a trigonal planer shape, so the 3 polar bonds (B-F) will cancel out, creating a non-polar molecule.

Be-Cl and B-F are polar bonds due to differences in electronegativity. This causes the electrons to spend more of their time around one atom, causing slight charges.

(d) 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 ethene and bromine gases, given the average bond enthalpies in the table below.

Show your working and include appropriate units in your answer.

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

Bonds Broken (+ ΔH).

C = C 614

C – H x 4 4 x 414 2270

Br – Br 193 2463.

Bonds formed (– ΔH)

C – H x 4 4 x 414 1656

C – Br x 2 2 x 285 2226

C – C 346 2572

ΔH = 2463 – 2572

ΔH = – 109 KJ/mol.

M6

QUESTION TWO

(a) Hand warmers contain a supersaturated solution of sodium ethanoate which, when activated, crystallises and releases heat.

Circle the term that best describes this reaction.

exothermic **endothermic**

Give a reason for your choice.

Exothermic reactions produce heat. //

(b) (i) Glucose is made in plants during photosynthesis when carbon dioxide gas, $CO_2(g)$, and water, $H_2O(\ell)$, react to produce glucose, $C_6H_{12}O_6(aq)$, and oxygen gas, $O_2(g)$. The photosynthesis reaction can be represented by the following equation:

$$6CO_2(g) + 6H_2O(\ell) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g) \quad \Delta_r H° = 2803 \text{ kJ mol}^{-1}$$

Circle the term that best describes this reaction.

exothermic **endothermic**

Give a reason for your choice.

The reaction takes heat from the environment, which gives it a ~~pass~~ positive ΔH.

(ii) Calculate how much energy is absorbed or released in the photosynthesis reaction if 19.8 g of carbon dioxide gas, $CO_2(g)$, reacts completely with excess water, $H_2O(\ell)$, to form glucose, $C_6H_{12}O_6(aq)$, and oxygen gas, $O_2(g)$. n = 6

Show your working and include appropriate units in your answer.

$M(CO_2) = 44.0 \text{ g mol}^{-1}$

~~n = m/M~~ n = m/44 m = 264 g

~~Energy~~ Heat = 1658 KJ

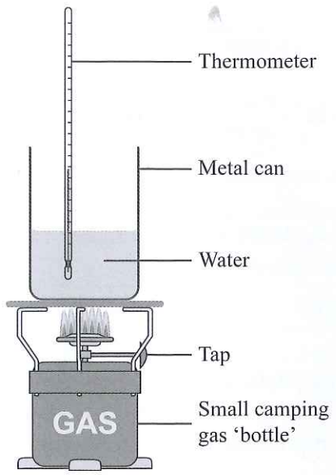
1 mol = 2803 KJ

n = 19.8/44 n = 0.45 mol

0.45 x 2803 = 1261.35 KJ.

(c) A small camp stove containing butane gas, $C_4H_{10}(g)$, is used to heat some water, as shown in the diagram below. A student measures the temperature change in the water and calculates that when 3.65 g of butane is combusted, 106 kJ of heat is released.

ASSESSOR'S USE ONLY



The reaction for the combustion of butane is shown in the equation below.

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(\ell)$$

(i) Calculate the enthalpy change ($\Delta_r H$) for this reaction, based on the above measurements.

$M(C_4H_{10}) = 58.0$ g mol^{-1}

$n = m/m_r$ $n = \frac{3.65}{58.0}$ $n = 0.0629$ mol (3sf)

0.0629 mol = 106 kJ

106 / 0.0629 = 1685.21 kJ mol^{-1}

$\Delta H = -1685.21$ kJ mol^{-1}

(ii) The accepted enthalpy change for the combustion reaction of butane gas, $C_4H_{10}(g)$, is $\Delta_r H = -5754$ kJ mol^{-1}.

ASSESSOR'S USE ONLY

Explain why the result you calculated in part (c)(i) is different to the accepted value.

In your answer, you should include at least TWO reasons.

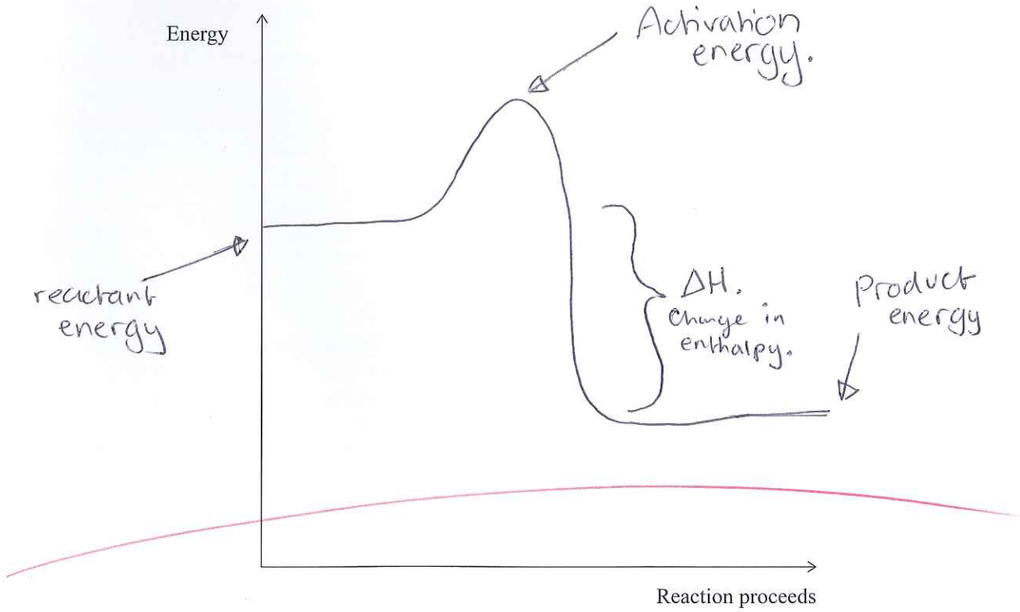
~~Human error in reading the~~

The metal can could absorb a large amount of heat, as metals are good heat conductors. //

Also energy is transfered to the thermometer in order for the liquid to expand. //

Human error when reading ~~thermometer~~ thermometer. //

(iii) Complete, including labels, the energy diagram for the combustion of butane gas showing reactants, products, and the change in enthalpy.



(iv) Butane gas is a useful fuel because when it undergoes combustion, energy is released.

Explain why energy is released in this reaction, in terms of making and breaking bonds.

No calculations are required.

ASSESSOR'S USE ONLY

When butane's bonds break, energy is taken from the environment, however, when new bonds are made in the products, a larger amount of energy is released, ~~else~~ causing an exothermic reaction.

The energy released from making bonds is greater than the energy used breaking bonds.

M6

QUESTION THREE

ASSESSOR'S USE ONLY

(a) Complete the table below by stating the type of solid, the type of particle, and the attractive forces between the particles in each solid.

Solid	Type of solid	Type of particle	Attractive forces between particles
Cu(*s*) (copper)	Metallic	Atom	Metallic
$PCl_3(s)$ (phosphorus trichloride)	Molecular	Molecular	weak inter-molecular forces.
$SiO_2(s)$ (silicon dioxide)	~~Ionic~~ molecular	~~Ions~~ molecular	Covalent network
KCl(*s*) (potassium chloride)	Ionic	Ions	ionic

(b) Phosphorus trichloride, PCl_3, is a liquid at room temperature, and does not conduct electricity.

Explain these two observations in terms of the particles, structure, and bonding of PCl_3.

The substance will be liquid at room temperature due to the weak intermolecular forces. These bonds do not require much energy ~~to~~ to break and will thus have a very low melting point. PCl_3 will not be conductive because when liquid it does not have any free moving charged particles (ions or electrons). This is because of the covalent bonding between P and Cl.

(c) Consider each of the solids copper, Cu, silicon dioxide, SiO_2, and potassium chloride, KCl.

ASSESSOR'S USE ONLY

Complete the table below by identifying which of these solids have the listed physical properties:

Physical properties	Solid
The solid is insoluble in water and is malleable.	Copper, Cu
The solid is soluble in water and is not malleable.	KCl
The solid is insoluble in water and is not malleable.	SiO_2

Justify TWO of your choices in terms of the particles, structure, and bonding of these solids. You may use diagrams in your justification.

Copper will be ~~not~~ malleable due to it's metallic bonding. The atoms are held tightly in a 3D lattice shape, ~~not are~~ but can slide past eachother under pressure. Copper is not soluble in water due to the strong attractive forces which bond metal's atoms together. 4

KCl is not malleable due to it's hard crystal structure, due to ionic bonding. Ionic 3D lattices are brittle because if the atoms slide past eachother, they will repel away (breaking structure), as they will come in contact with a like-charged particle. e.g. K^+ meets K^+. KCl will be soluble in water because the polarity of the water means that the attractive forces between H_2O and K^+ and H_2O and Cl^- are stronger than the attractive forces between K^+ and Cl^-. Water will pull the ions apart.

A4

Extra paper if required.
Write the question number(s) if applicable.

QUESTION NUMBER

ASSESSOR'S USE ONLY

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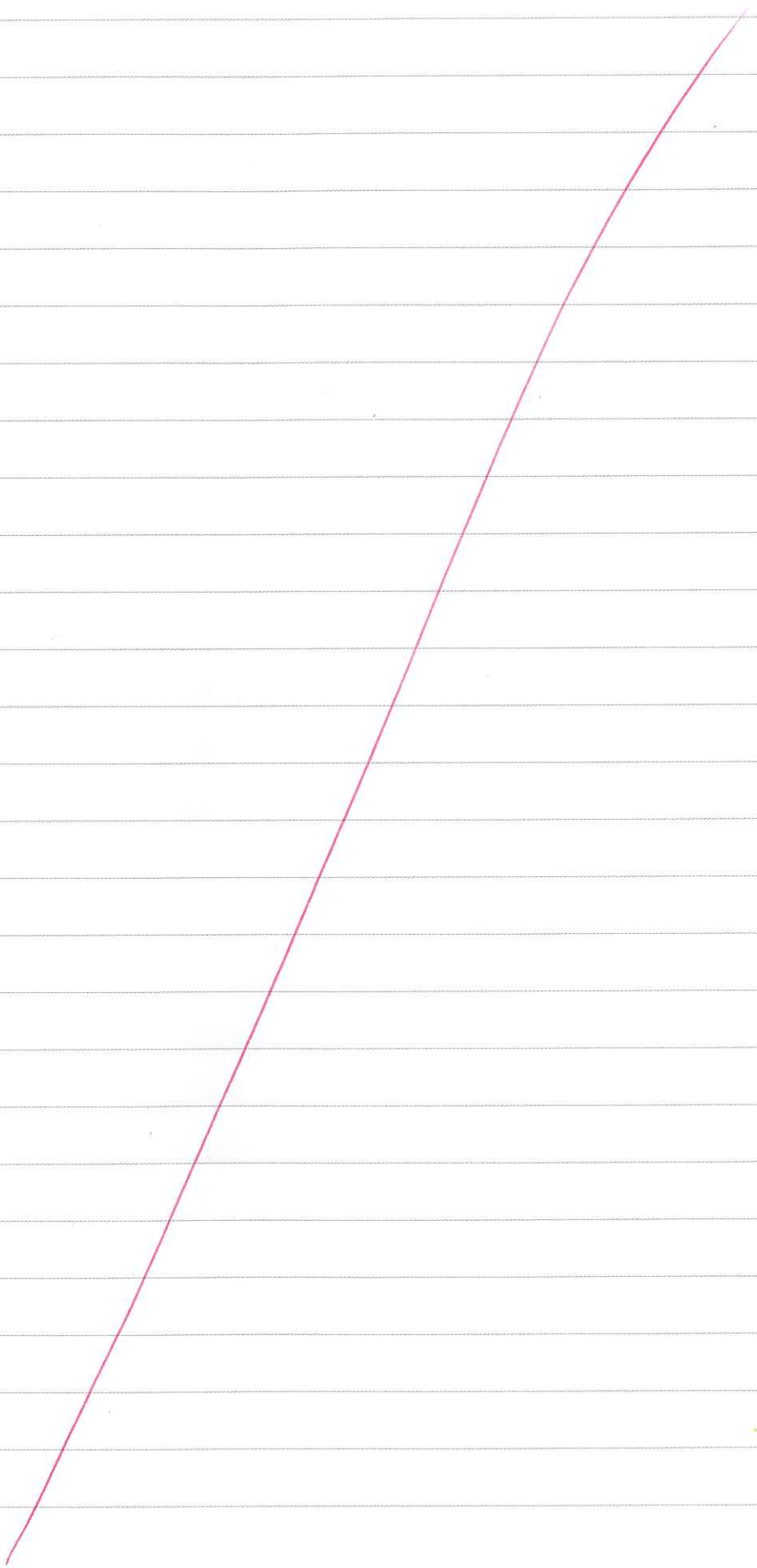

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High Merit

TOTAL 17

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QUESTION ONE

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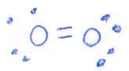
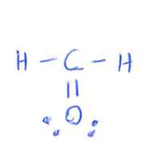
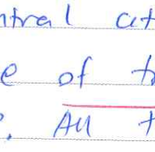
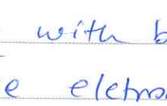
(a) Draw the Lewis structure (electron dot diagram) for each of the following molecules.

Molecule	O_2	OCl_2	CH_2O
Lewis structure			

(b) 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.

Molecule	CCl_4	$COCl_2$
Lewis structure		

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.

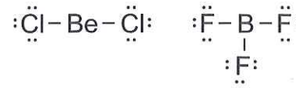
~~The~~ CCl_4 has four regions of electron density around the central atom C therefore it has a parent shape of tetrahedral and bond angles of 109.5°. All ~~four~~ of these ~~or~~ electron density regions are bonding therefore the ~~shape~~ actual shape of the CCl_4 molecule is also tetrahedral. //

$COCl_2$ has three regions of electron density around the central atom ~~O~~ C therefore it has a parent shape of trigonal planar with bond angles of 120°. All three of these electron

density regions are bonding therefore the molecule has an actual shape of trigonal planar. //

ASSESSOR'S USE ONLY

(c) $BeCl_2$ and BF_3 are unusual molecules because there are not enough electrons for the central atoms, Be and B, to have a full valence shell. Their Lewis structures are shown below.



Both molecules have the same polarity.

Circle the word that describes the polarity of these molecules.

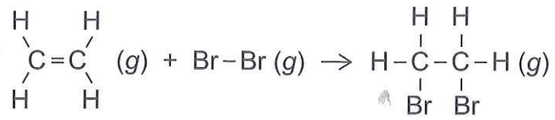
polar **non-polar**

Justify your choice.

~~Both~~ $BeCl_2$ is non polar because it has 2 ~~two~~ polar bonds due to the difference in electronegativity between Be and Cl but these dipoles cancel out due to the symmetrical linear shape of $BeCl_2$.

BF_3 ~~also has~~ is also non polar because it has 3 polar bonds due to the difference in electronegativity between B and F however these dipoles also cancel out due to the symmetrical trigonal planar shape of BF_3. //

(d) 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 ethene and bromine gases, given the average bond enthalpies in the table below.

Show your working and include appropriate units in your answer.

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

Bonds broken − bonds formed

$((414 \times 4) + 614 + 193) - ((414 \times 4) + (285 \times 2) + 346)$

$= (1656 + 614 + 193) - (1656 + 570 + 346)$

$= 2463 - 2572$

$= -109$ kJ mol^{-1}

ASSESSOR'S USE ONLY

QUESTION TWO

(a) Hand warmers contain a supersaturated solution of sodium ethanoate which, when activated, crystallises and releases heat.

Circle the term that best describes this reaction.

exothermic **endothermic**

Give a reason for your choice.

because the reaction releases heat energy.

(b) (i) Glucose is made in plants during photosynthesis when carbon dioxide gas, $CO_2(g)$, and water, $H_2O(\ell)$, react to produce glucose, $C_6H_{12}O_6(aq)$, and oxygen gas, $O_2(g)$. The photosynthesis reaction can be represented by the following equation:

$$6CO_2(g) + 6H_2O(\ell) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g) \quad \Delta_r H° = 2803 \text{ kJ mol}^{-1}$$

Circle the term that best describes this reaction.

exothermic **endothermic**

Give a reason for your choice.

because the B_2 enthalpy ($\Delta_r H°$) is positive

(ii) Calculate how much energy is absorbed or released in the photosynthesis reaction if 19.8 g of carbon dioxide gas, $CO_2(g)$, reacts completely with excess water, $H_2O(\ell)$, to form glucose, $C_6H_{12}O_6(aq)$, and oxygen gas, $O_2(g)$.

Show your working and include appropriate units in your answer.

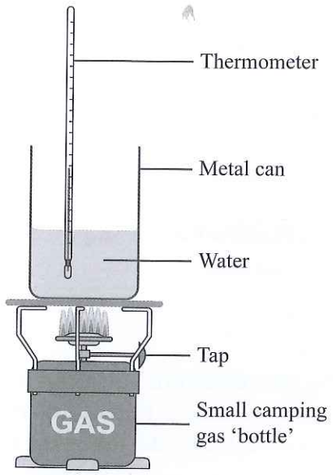
$M(CO_2) = 44.0$ g mol^{-1}

$\frac{19.8}{44} = 0.45$ mols

$2803 \times 0.45 = 1261.35$ kJ

ASSESSOR'S USE ONLY

(c) A small camp stove containing butane gas, $C_4H_{10}(g)$, is used to heat some water, as shown in the diagram below. A student measures the temperature change in the water and calculates that when 3.65 g of butane is combusted, 106 kJ of heat is released.



The reaction for the combustion of butane is shown in the equation below.

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(\ell)$$

(i) Calculate the enthalpy change ($\Delta_r H$) for this reaction, based on the above measurements.

$M(C_4H_{10}) = 58.0$ g mol^{-1}

~~58~~ $\frac{58}{3.65} = 15.89$

$106 \times 15.89 = 1684.34$ kJ

$1684.34 \times 2 = 3368.68$

$\Delta_r H = -3368.68$ kJ mol^{-1}

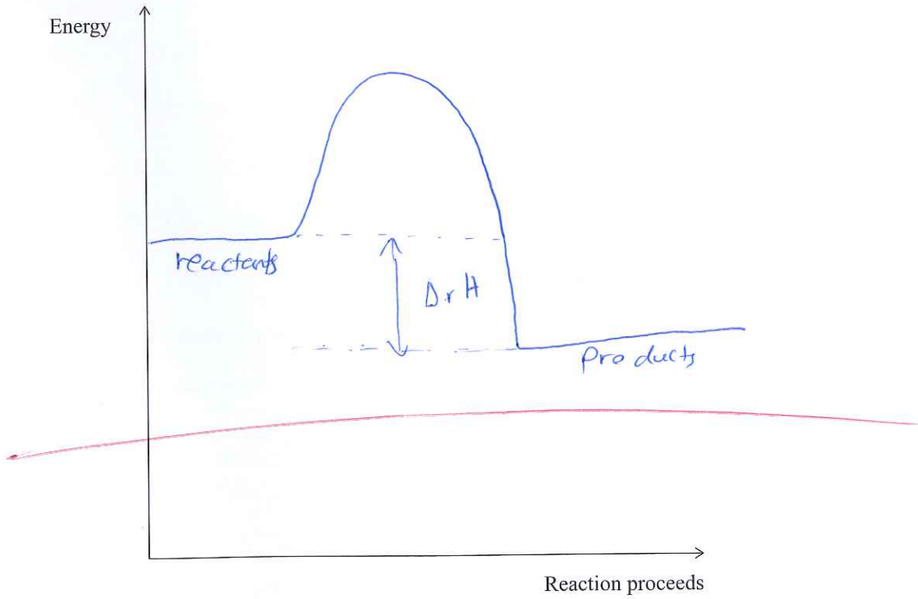
ASSESSOR'S USE ONLY

(ii) 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 the result you calculated in part (c)(i) is different to the accepted value.

In your answer, you should include at least TWO reasons.

(iii) Complete, including labels, the energy diagram for the combustion of butane gas showing reactants, products, and the change in enthalpy.



ASSESSOR'S USE ONLY

(iv) Butane gas is a useful fuel because when it undergoes combustion, energy is released.

Explain why energy is released in this reaction, in terms of making and breaking bonds.
No calculations are required.

Energy is released because more bonds are formed rather than broken
Energy is released because more bonds are broken than formed. This means the product have less energy than the reactants, the excess energy is released.

ASSESSOR USE ONLY

QUESTION THREE

ASSESSOR'S USE ONLY

(a) Complete the table below by stating the type of solid, the type of particle, and the attractive forces between the particles in each solid.

Solid	Type of solid	Type of particle	Attractive forces between particles
Cu(*s*) (copper)	metallic	atoms	metallic bonds
$PCl_3(s)$ (phosphorus trichloride)	molleecular	molecules	intermolleculer forces
$SiO_2(s)$ (silicon dioxide)	Cavalent network	atoms	covalent bonding
KCl(*s*) (potassium chloride)	ionic	anions and cations	ionic bonding.

(b) Phosphorus trichloride, PCl_3, is a liquid at room temperature, and does not conduct electricity.

Explain these two observations in terms of the particles, structure, and bonding of PCl_3.

PCl_3 is a molleecular solid made out of molecules held together by weak intermolleculer forces. The attractive forces between these molecules that even at room temperature they can be broken and the PCl_3 exists as a liquid at room temperature. Also PCl_3 does not conduct any electricity because it does not have any free particles capable of carrying a charge like electrons or ions, it is made out of just molecules.

A4

(c) Consider each of the solids copper, Cu, silicon dioxide, SiO_2, and potassium chloride, KCl.

Complete the table below by identifying which of these solids have the listed physical properties:

Physical properties	Solid
The solid is insoluble in water and is malleable.	~~metal~~ Cu
The solid is soluble in water and is not malleable.	KCl
The solid is insoluble in water and is not malleable.	SiO_2

Justify TWO of your choices in terms of the particles, structure, and bonding of these solids. You may use diagrams in your justification.

Cu is a metal made out of atoms in a sea of free electrons held together by ~~ionic~~ metallic bonding. ~~The particles in~~ The Cu atoms are not attracted to the H_2O molecules and the metallic bonding is very strong so ~~the~~ Cu is ~~not~~ insoluble. Also the metallic bonding is a non directional attractive force therefore if pressure is applied the bonds are not broken they are simply ~~not~~ redistributed. This makes Cu malleable. ~~SiO2~~ KCl is an ionic substance that is made out of anions and cations in a 3d lattice network held together by ionic bonds. The negative anions are attracted to the slightly positive H side of water molecules and the positive cations are attracted to the slightly negative O side of the water molecules therefore ~~for~~ KCl is soluble in water. KCl is held in a 3d lattice by strong ionic bonds ~~and SiO2 these bonds are~~ which are a direction attractive force therefore if pressure is applied there will be repulsion and the KCl will shatter

ASSESSOR'S USE ONLY

M6

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