2

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91164

911640

NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
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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 Achievement

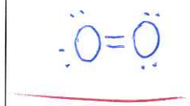
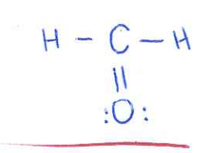
TOTAL 11

ASSESSOR'S USE ONLY

QUESTION ONE

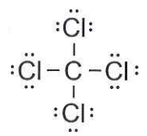
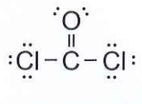
ASSESSOR'S USE ONLY

(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.

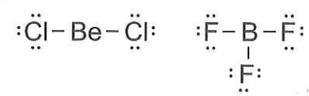
CCl_4 is trigonal planar and has a bond angle of 120°. The C-Cl bonds are polar as they have a different electronegativity but as Carbon has four electron densitys around it, which are all bonding, the shape of the molecule is trigonal planar with a bond angle of 120°.

$COCl_2$ is a trigonal pyramid with a bond angle of 109°. The C-Cl and C-O bonds are polar as they differ in electronegativity as well. The C has four electron densitys around it which are all bonding but two of which are to the O making the

Molecule a trigonal pyramid and has a bond angle of 109°.

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.

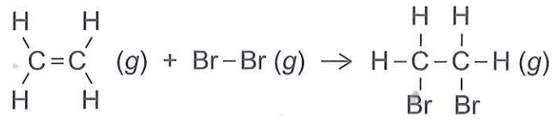
Circle the word that describes the polarity of these molecules.

polar **non-polar**

Justify your choice.

Both $BeCl_2$ and BF_3 are polar molecules. The Be-Cl bonds in $BeCl_2$ and the B-F bonds in BF_3 are polar due to the difference in electronegativity. The Be has two bonding electron densities around it forming the Chlorines to be symmetrical. B has three electron densities around it which are all bonding but the F atoms can not be symmetrical. As there are not enough electrons for the central atoms and BF_3 is not symmetrical, the bond dipoles must cancel out making both the molecules polar.

(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.

$\Delta_r H°$ = Bonds broken − bonds formed

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

Bonds broken

4x C-H = 414 x4 = 1656

1x C=C = 614 x1 = 614

1x Br-Br = 193 x1 = 193

1656 + 614 + 193 = 2463

Bonds formed

4x C-H = 414x4 = 1656

2x C-Br = 285 x2 = 570

1x C-C = 346 x1 = 346

1656 + 570 + 346 = 2570

$\Delta_r H° = 2463 - 2570$

$\Delta_r H° = -107 kJ mol^{-1}$ 1 d.p

ASSESSOR'S USE ONLY

A4

QUESTION TWO

ASSESSOR'S USE ONLY

(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 give off 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.

Heat is absorbed in this reaction making a positive enthalpy. positive = endothermic

(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.

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

$n = \frac{m}{M}$

$n = \frac{19.8g}{44.0 g mol^{-1}}$

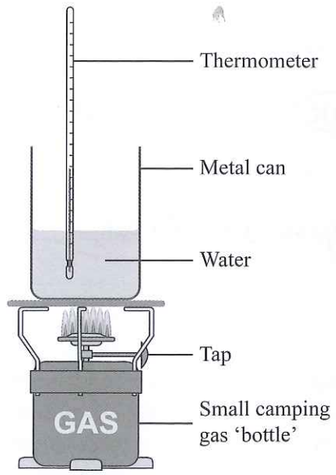
$= 0.45 kg$ $0.45_{kg} \times 2803_{kJmol^{-1}} = 1261.35$

$= 1261 kJ mol^{-1}$ (1dp)

is absorbed.

(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.

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

$n = \frac{m}{M}$ $n = \frac{3.65\text{g}}{58.0\text{gmol}^{-1}}$ $= 0.06293103448 \text{ kjmol}^{-1}$

$= 0.0629$ (3sf)

$0.0629 \times -106 = 6.671 \text{ KJmol}^{-1}$

$\Delta_r H = -6.671 \text{ kjmol}^{-1}$

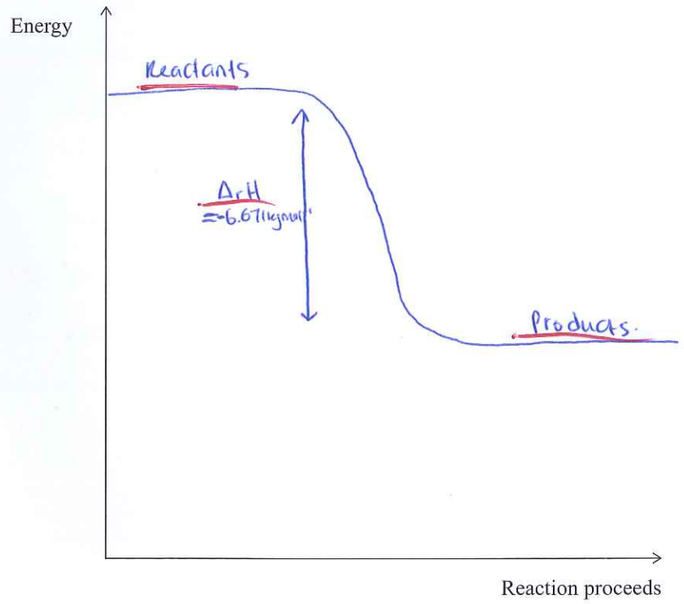
(ii) The accepted enthalpy change for the combustion reaction of butane gas, $C_4H_{10}(g)$, is $\Delta_r H = -5754 \text{ kJ mol}^{-1}$.

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.

(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.

Energy is released in this reaction as it is exothermic. The C-H bond's are broken along with the O-O bonds which form new bonds between C-O and H-O. this releases energy therefore making it useful when it undergoes combustion.

ASSESSOR'S USE ONLY

QUESTION THREE

(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	Possible metallic forces (positive + negative)
$PCl_3(s)$ (phosphorus trichloride)	molecular	Molecule	weak intermolecular forces
$SiO_2(s)$ (silicon dioxide)	Covalent network	atoms	covalent bonds
KCl(*s*) (potassium chloride)	ionic	ionic	ionic bonds

(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.

As PCl_3 is a molecular solid it does not conduct electricity. The molecules form in a 3D lattice ~~structure~~ meaning there are no free moving electrons that conduct the electricity. It's weak intermolecular forces means that bonds can easily be broken within the molecule, but at room temperature when PCl_3 is a liquid there are still no freely moving particles within the molecule so it can not conduct electricity.

ASSESSOR'S USE ONLY

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.	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 insoluble in water ~~and is a~~ as it is a metallic solid. The atoms within Cu form a 3D lattice ~~which~~ so it ~~is~~ can not ~~impossible to~~ break the bonds of this solid so that it is soluble in water. Although it is not soluble, it is malleable. The bonds within this 3D lattice are able to be hit and still remain attached. This just changes the shape of the Cu solid.

KCl is soluble in water as it is able to convert into a liquid. ~~The ionic bonding~~ The ionic solid forms a 3D lattice where the bonds are easily broken making KCl soluble in water. KCl is not malleable as the bonds within the 3D lattice are easily broken so you can not change its shape.

ASSESSOR'S USE ONLY

A3

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

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2

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High Achievement

TOTAL 12

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QUESTION ONE

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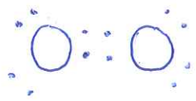
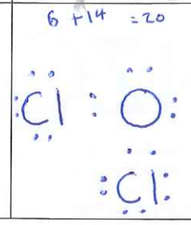
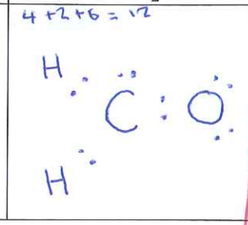
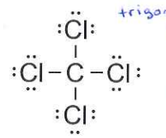
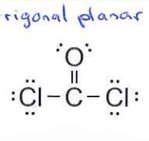
(a) Draw the Lewis structure (electron dot diagram) for each of the following molecules.

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:

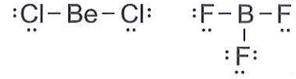
- the approximate bond angle in each molecule
- the shape of each molecule
- factors that determine the shape and bond angle for each molecule.

- In the CCl_4 molecule there are 4 regions of electrons surrounding each of the atoms. There they will arrange themselves in a trigonal pyramidal arrangement because of the repulsion of the electrons. Therefore the bond angle will approximately be 109°
- In the $COCl_2$ molecule there are only ~~there~~ 3 regions of electrons surrounding the 4 atoms. To minimise repulsion

the atoms will arrange themselves in a trigonal planar arrangement with an approximate bond angle of 120°.

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.

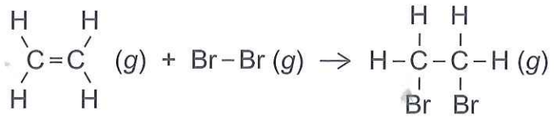
Circle the word that describes the polarity of these molecules.

polar **non-polar**

Justify your choice.

- Each of these molecules are non-polar molecules. They each have an even distribution of charge throughout the molecule. In the $BeCl_2$ the molecule is arranged a linear because each of the Chlorine atoms have the same amount of electrons surrounding them, this therefore gives an even distribution of charge and a non-polar molecule. The BF_3 has 3 regions of electron density and each of the surrounding F atoms have the same number of electrons surrounding the B atom. Therefore there is an even distribute of charge, meaning it is a non-polar molecule.

(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

$\Delta_r H°$ = (bonds broken − bonds made)

(C=C) + 4(C-H) + (Br-Br) − (C-C) + 2(C-Br) + 4(C-H)

= (614) + 4(414) + (193) − (346) + 2(285) + 4(414)

= (614) + (1656) + (193) − (346) + (570) + (1656)

= 2463 − 2572

= −109 kJ mol^{-1}

M5

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.

exothermic reactions release heat into the environment (heat up).

(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.

a positive $\Delta_r H°$ value means energy is being taken from the environment (getting colder).

(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.

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

4.18 C

$n = \frac{m}{M}$

$n = \frac{19.8}{44}$

$n = 0.45$ mol

$\Delta H = \frac{\Delta E}{n}$

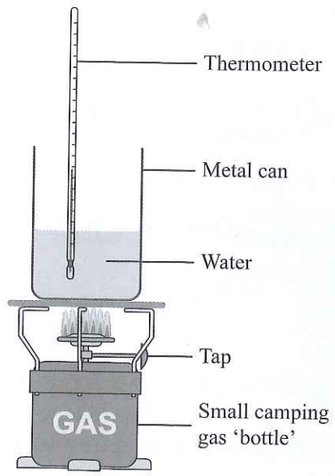
$\Delta H = \frac{44}{0.45}$

$\Delta H = 97.8$ J

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.

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}

$n = \frac{m}{M}$ $n = \frac{3.65}{58}$

$n = 0.063$ mol

$\Delta_r H = \Delta H \times n$ $\Delta_r H = 106 \times 0.063$

$\Delta_r H = 6.678$ 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}.

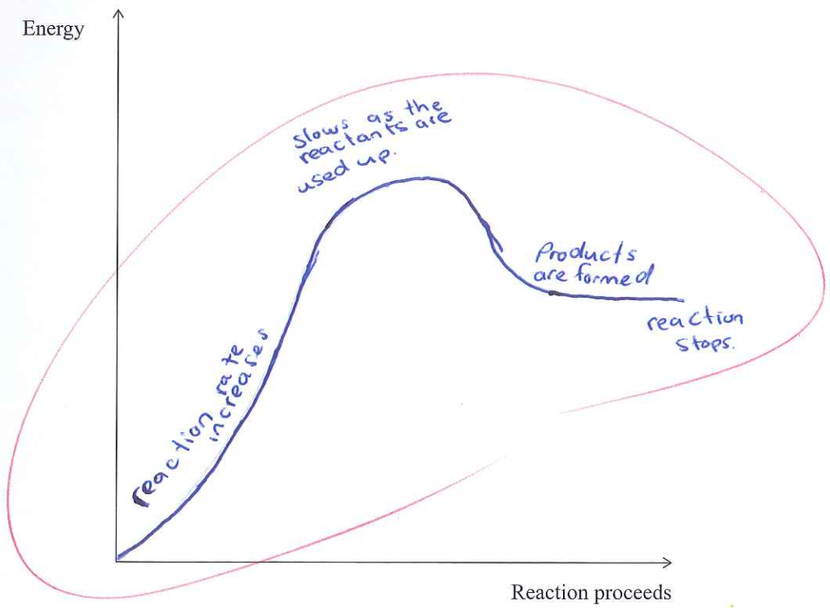
ASSESSOR'S USE ONLY

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.

- the two answers will be different because of factors such as the environment. Heat given out by the reaction will not all go ~~the~~ to heating the water.
- also the combustion reaction may not be complete, the reactants might not fully react to ~~g~~ produce as much heat, there the $\Delta_r H$ will be less.

(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.

Butane combustion reaction is useful because the energy from breaking the bonds is more than forming the bonds, therefore there can be more energy released in the reaction to give out heat.//

ASSESSOR'S USE ONLY

A4

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 (metal)	metallic bonds
$PCl_3(s)$ (phosphorus trichloride)	molecule	molecules (atoms)	molecular bonds
$SiO_2(s)$ (silicon dioxide)	covalent network	atoms	Covalent bonds
KCl(*s*) (potassium chloride)	ionic	Ions	Ionic bonds

(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 molecule, it has weak intermolecular bonds holding the structure together. At room temperature these bonds are strong enough to hold the molecule together because there is not heat acting on it. This molecule doesn't conduct electricity because there are no free moving valence electrons, therefore the is no way for electricity to travel through the molecule.//

(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.	Copper, Cu
The solid is soluble in water and is not malleable.	Potassium Chloride, KCl
The solid is insoluble in water and is not malleable.	Silicon dioxide, 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 is insoluble in water because of the covalent bond between the metal solid, these bonds are strong enough that the water will not effect the bonds and it won't dissolve. Copper is malleable because it has free valence electrons that are able to slid over each other when pressure is applied, therefore the solid is malleable.//
- Potassium is ~~an~~ is soluble in water because the weak ionic bonds are effected ~~bcos~~ by the molecular bonds in the water molecule. Therefore this solid will dissolve in water. KCl is ~~also~~ not malleable because it has no free moving valence electrons. when pressure is applied the solid will break because the particle within the solid are unable ~~bcos~~ to slid of moved across each other.//

ASSESSOR'S USE ONLY

A3

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

QUESTION NUMBER

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QUESTION NUMBER

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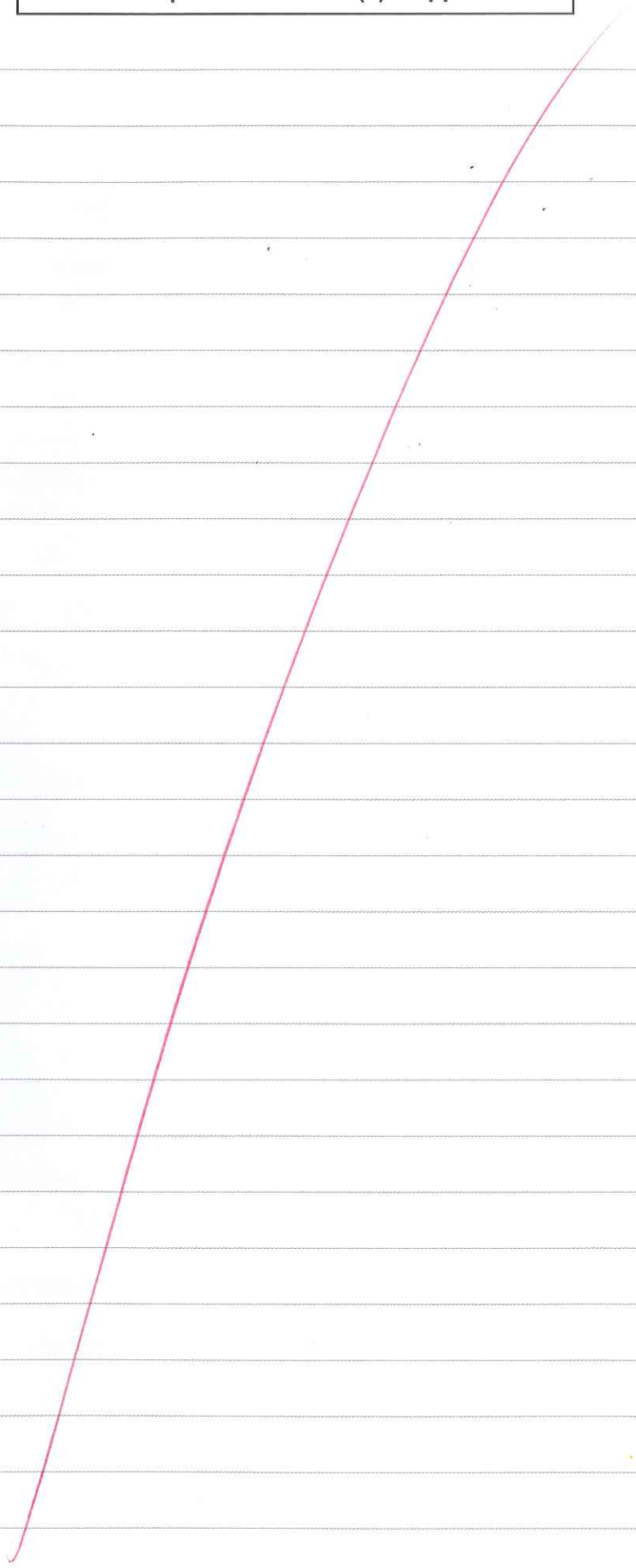

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