No part of the candidate evidence in this exemplar material may be presented in an external assessment for the purpose of gaining credits towards an NCEA qualification.

3

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91390

913900

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Level 3 Chemistry, 2015

91390 Demonstrate understanding of thermochemical principles and the properties of particles and substances

2.00 p.m. Wednesday 11 November 2015
Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of thermochemical principles and the properties of particles and substances.	Demonstrate in-depth understanding of thermochemical principles and the properties of particles and substances.	Demonstrate comprehensive understanding of thermochemical principles and the properties of particles and substances.

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 L3–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 2–11 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.

High Merit

TOTAL 18

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Annotated Exemplar Template

exemplar for 901390 2015	Total score	18

Q	Grade score	Annotation
1	**E7**	1b) correct definitions 1c) has clearly linked increased nuclear charge to increase in protons. Links increased attraction to more electrons being drawn in closer and a smaller radii.. Clearly states that electrons are being added to the same energy level. Omits to mention the electrostatic attraction between nucleus and electrons.
2	**M6**	2a) i) correct equation with states. ii) recognises that the equations are the same b) Recognises that energy is required to break the intermolecular bonds in the gas phase and links to the fact that as this energy is being absorbed it is not released to the surroundings c) correct with units
3	**M5**	a) Correct structures and names b) States number of electron density areas, states parent geometry and links to repulsion between bonding electrons. States actual geometry, linked to number of bonding and non-bonding electrons. Gives the reason for bond polarity as being a difference in electronegativity. Gives the polarity of the molecule and links to symmetry and dipoles cancelling/ not cancelling. c) Ii) States that both molecules have the same sized electron cloud and similar sized temporary dipoles. Limited explanation for the strength of hydrogen bonding. Wrongly assigns permanent dipoles to only one molecule.

1s
2s 2p
3s 3p 3d
4s 4p

QUESTION ONE

(a) Complete the following table.

Symbol	Electron configuration
13 Al	$1s^2 2s^2 2p^6 3s^2 3p^1$
29-2 Cu^{2+}	$1s^2 2s^2 2p^6 3s^2 3p^6$ ~~4s~~ $3p^9$
21 Sc	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3p^1$

(b) Define the terms electronegativity and first ionisation energy.

Electronegativity: It ~~is~~ measures the strength of the attraction of a positive nucleus of an atom for a pair of bonding electrons. The greater the force of attraction, the higher the electronegativity

First ionisation energy: It is the energy required to remove 1 mole of electrons from 1 mole of gaseous atoms. It is determined by nuclear charge and shielding effect

(c) The following table shows the first ionisation energy values for elements in the third period of the periodic table.

Element	First ionisation energy/kJ mol^{-1}
11 Na	502
13 Al	584
14 Si	793
18 Ar	1 527

↑ across period

Justify the periodic trend of first ionisation energies shown by the data in the table above, and relate this to the expected trend in atomic radii across the third period.

electron configuration Na $1s^2 2s^2 2p^6 3s^1$ Al $1s^2 2s^2 2p^6 3s^2 3p^1$

Si $1s^2 2s^2 2p^6 3s^2 3p^2$ Ar $1s^2 2s^2 2p^6 3s^2 3p^6$

All of four element have their valence electrons on 3rd energy level.

~~Ionisa~~ Ionisation energy increase across a period. As going across a period, nuclear charge density increases

For Na, it has ~~13~~ 11 protons attracting ~~13~~ 11 electrons, whereas ~~for~~ for Al, Si they have 13 and 14 protons attracting 13 and 14 electrons respectively. Although there is also increase in electron across the period, as the electrons are being added to the same energy level, the electron shielding remains the same. As a result, the increased protons draws the valence electrons closer to nucleus, and held ~~them more tightly~~ decreasing the radii of atoms.

Therefore, the ~~radii~~ atomic radii also decrease across the period ~~as~~

The ~~a force~~ attraction force between nucleus and valence ~~e~~ electrons increase as nuclear charge increase (across a period). As a result, more ~~to~~ energy is required to break the attraction between the nucleus and valence electrons

Ar is a inert gas and it has its valence orbital full. Therefore the attraction between its nucleus and valence electrons is far stronger. Therefore, a great amount of energy is required to break this attraction ($1527\ kJ\ mol^{-1}$)

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E7

QUESTION TWO

The equation for $\Delta_f H°$ of $H_2O(\ell)$ is:

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(\ell) \qquad -286\ \text{kJ mol}^{-1}$$

(a) (i) Write the equation for $\Delta_c H°$ ($H_2(g)$).

$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta_c H° = -286\text{kJ mol}^{-1}$

(ii) Using the equations above, explain why $\Delta_c H°$ (H_2) and $\Delta_f H°$ (H_2O) have the same value of -286 kJ mol^{-1}.

~~The elements~~ ~~for~~

The ~~elements~~ ~~for both~~ equ

The reactants for both equation are ~~the~~ the same and ~~in~~ exactly the same proportion. Therefore when the same elements react, the energy released are the same

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(b) The enthalpy of formation would change if the water was formed as a gas rather than a liquid.

(i) Circle the correct phrase to complete the sentence below.

$\Delta_f H°$ ($H_2O(g)$) is:

less negative than / the same as / more negative than $\Delta_f H°$ ($H_2O(\ell)$).

(ii) Justify your choice.

Energy is required to convert water from liquid to gas. The energy required is used to break ~~to~~ the attraction between water molecules.

As more energy is used to break the attraction between water molecules, less energy is released to the surrounding during the process. Therefore, the $\Delta_f H°(H_2O_{(g)})$ is less negative than $\Delta_f H°(H_2O_{(l)})$.

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(c) Calculate the $\Delta_f H^\circ$ for $B_2H_6(g)$, given the following data:

$\Delta_f H^\circ$ ($B_2O_3(s)$) $= -1255$ kJ mol^{-1}

$\Delta_f H^\circ$ ($H_2O(\ell)$) $= -286$ kJ mol^{-1}

$B_2H_6(g) + 3O_2(g) \rightarrow B_2O_3(s) + 3H_2O(\ell)$ $\quad \Delta_r H^\circ = -2148$ kJ mol^{-1}

The melting point of boron is 2300°C.

(i) $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$ ~~-286 kJ mol~~$^{-1}$ $\Delta_f H^\circ(H_2O)_l = -286$ kJ mol^{-1}

(ii) $2B_{(g)} + \frac{3}{2}O_{2(g)} \rightarrow B_2O_{3(s)}$ $\Delta_f H^\circ(B_2O_{3(s)}) = -1255$ kJ mol^{-1}

(iii) 3 × (i) $3H_2O_{(l)} \rightarrow 3H_{2(g)} + \frac{3}{2}O_{2(g)}$ $\Delta_f H = 858$ kJ mol^{-1}

~~$B_2H_{6(g)} + 3O_{2(g)} + 2B_{(g)} + \frac{3}{2}$~~

(iv) $B_2O_{3(s)} \rightarrow \frac{3}{2}O_{2(g)} + 2B_{(g)}$ $\Delta_f H = 1255$ kJ mol^{-1}

(iii) + (iv) $3H_2O_{(l)} + B_2O_{3(s)} \rightarrow 3H_2 + \frac{3}{2}O_{2(g)} + \frac{3}{2}O_{2(g)} + 2B_{(g)}$ $\Delta_f H = 2113$ kJ mol^{-1}

$B_2H_{6(g)} + \cancel{3O_{2(g)}} + \cancel{3H_2O} + \cancel{B_2O_{3(s)}} \rightarrow 3H_2 + \cancel{3O_{2(g)}} + 2B_{(g)} + \cancel{B_2O_{3(s)}} + \cancel{3H_2O_{(l)}}$

$B_2H_{6(g)} \rightarrow 3H_{2(g)} + 2B_{(g)}$ $\Delta_f H = -35$ kJ mol^{-1}

$3H_{2(g)} + 2B_{(g)} \rightarrow B_2H_{6(g)}$ $\Delta_f H = 35$ kJ mol^{-1}

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QUESTION THREE

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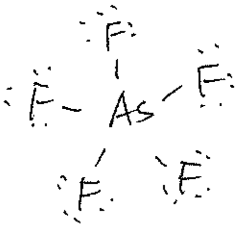
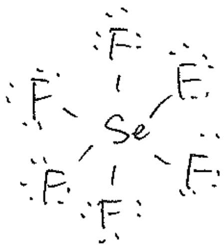
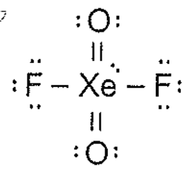
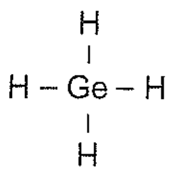
(a) Complete the following table.

	AsF$_5$ 5 7 40	SeF$_6$ 6 7 48
Lewis diagram		
Name of shape	trigonal bipyramid	Octahedral

(b) The Lewis diagrams and shapes for XeO_2F_2 and GeH_4 are shown below.

P 

see-saw

NP 

tetrahedral

Compare and contrast the polarities and shapes of these two molecules.

XeO_2F_2 has 5 electron density around the central Xe atom Whereas GeH_4 has 4 electron density around the central Ge atom. For minimum repulsion, ~~XeO_2F_2~~ ~~they~~ they move as apart as possible to the corner of triagonal bipyramid in XeO_2F_2 and to the corner of tetrahedral in GeH_4.

Both molecules has ~~For XeO_2F_2 there~~ are 4 bonding electron whereas for XeO_2F_2 it also has one lone pairs. Therefore, the shape of XeO_2F_2 is see-saw and the shape of GeH_4 is tetrahedral.

Both ~~XeO_2~~F_2 molecules have polar bonds. For XeO_2F_2 it has two polar F–O (F is more electronegative than O atom) and Xe=O bond (O is more electronegative than Xe). For GeH_4 it has 4 polar Ge–H bond (H is more electronegative than Ge) ~~As~~ Therefore, ~~the~~ the bond dipoles forms

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the spread of electron density in XeO_2F_2 is asymmetrical ~~wh~~
Whereas ~~the~~ the spread of electron density in GeH_4 is
symmetrical.
therefore bond dipoles in XeO_2F_2 do not cancel out but
bond dipoles in GeH_4 cancel out.
As a result XeO_2F_2 is a polar molecule GeH_4 is a
non-polar molecule.

Question Three continues on the following page.

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(c) The two molecules below have the same molecular formula ($C_5H_{12}O$) but have different boiling points.

MOP

Name	Pentan-1-ol	Dimethylpropan-1-ol
Structure	$CH_3-CH_2-CH_2-CH_2-CH_2-OH$	$CH_3-C(CH_3)_2-CH_2-OH$
Boiling point	138°C	113°C

(i) List all the forces of attraction between these molecules in each of their liquid states.

Temporary dipoles - Temporary dipoles force

Permanent dipoles - permanent dipoles force

H bonds

(ii) Use the information above to explain the difference in the boiling points of pentan-1-ol and dimethylpropan-1-ol by comparing and contrasting the relative strengths of the attractive forces between the molecules involved.

Boiling point ~~Both molecule~~ is the measure of the strength of the intermoleculer force ~~the stronger the force~~ ~~larger the boiling point the~~ the ~~The~~ of attraction the higher the boiling point.

As pentan-1-ol and dimethylpropan-1-ol have same number of electrons. They have same sized electron cloud Therefore. they have temporary dipole - temporary dipole force which are of similar strength.

Both of pentan-1-ol ~~molecule~~ and dimethylpropan-1-ol have C-H polar bond (C is more electronegative than H). and bond dipoles do not cancel. Thus both of them has permanent dipole - permanent dipole force. As pentan-1-ol has more C-H ~~polar~~ bonds than dimethylpropan-1-ol. The permanent dipole-dipole force for pentan-1-ol is stronger.

Both of pentan-1-ol and dimethypropan-1-ol can form H bond as H atom is directly attached to O atom Thus the force of attraction between molecules are very high and a large amount of energy is required to break it.

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(d) The equation for the combustion of pentan-1-ol is:

$$C_5H_{12}O(\ell) + 7\tfrac{1}{2}O_2(g) \rightarrow 5CO_2(g) + 6H_2O(\ell)$$

Calculate $\Delta_c H°$ for pentan-1-ol, given the following data:

$\Delta_f H°\ (C_5H_{12}O(\ell)) = -295\ kJ\ mol^{-1}$

$\Delta_f H°\ (CO_2(g)) = -394\ kJ\ mol^{-1}$

$\Delta_f H°\ (H_2O(\ell)) = -286\ kJ\ mol^{-1}$

$\Delta cH = \Sigma$ product $- \Sigma$ reactant

$\Delta cH = 5 \times (-394) + 6 \times (-286) - (-295) = -3391\ kJmol^{-1}$

Both molecules have three type force of attraction between the molecule. However, as the temporary dipole-dipole force for pentan-1-ol is stronger. Its boiling point is higher (138°C) than dimethylpropan-1-ol (113°C)

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