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3

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.

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Low Achievement

TOTAL

8

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QUESTION ONE

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- (a) Complete the following table.

Symbol	Electron configuration
Al	$1s^2 2s^2 2p^6 3s^2 3p^1$
Cu^{2+}	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$
Sc	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^1 4s^2$

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

Electronegativity: The ability for an atom to attract bonding electrons

First ionisation energy: The energy required to remove 1 mol of the least tightly bound electron in an atom/ion in a gaseous state

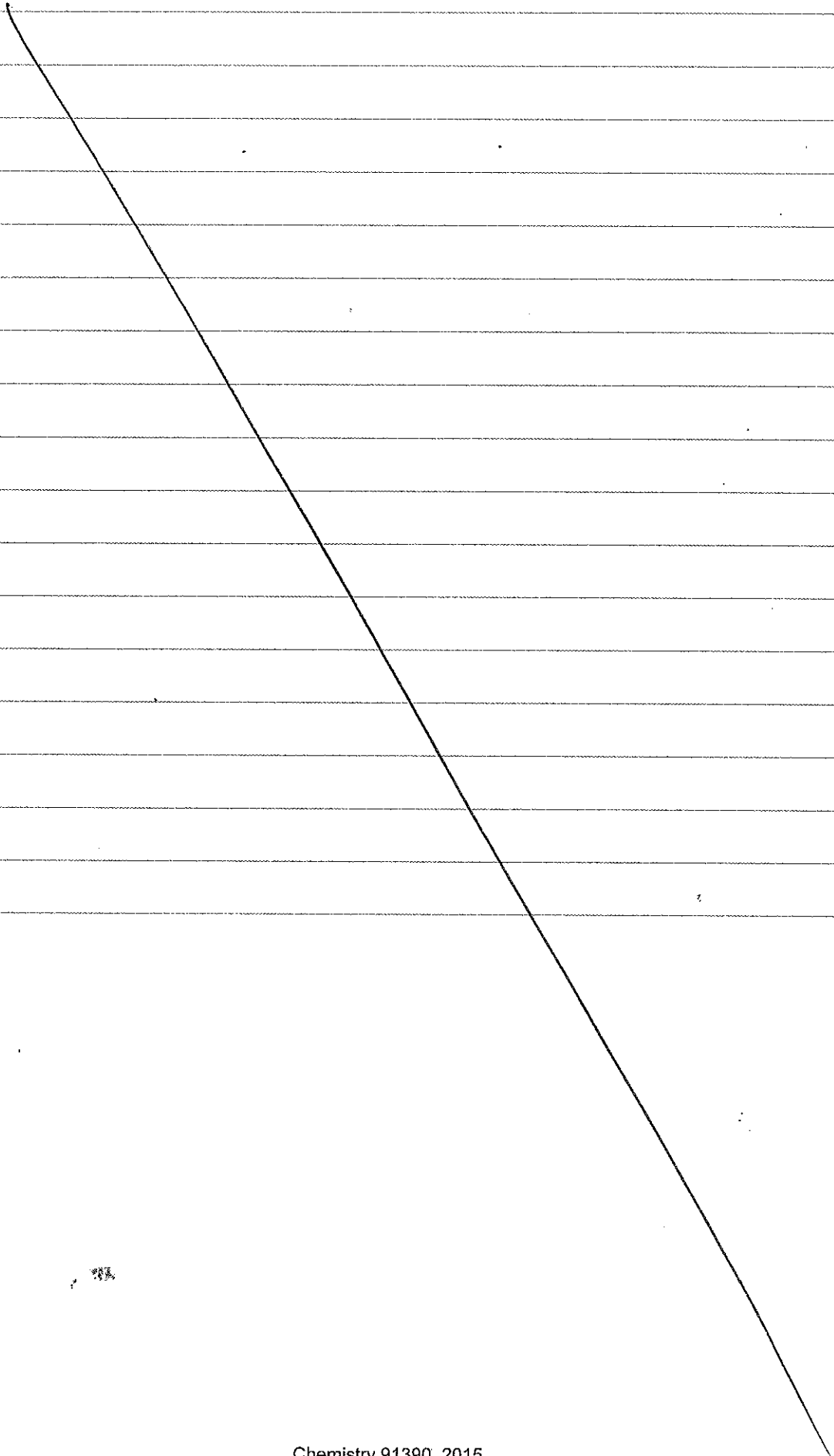
- (c) The following table shows the first ionisation energy values for elements in the third period of the periodic table.

Element	First ionisation energy / kJ mol^{-1}
Na	502
Al	584
Si	793
Ar	1527

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.

The first ionisation energy increases across a group because the effective charge of the nucleus (number of protons) increases, becoming greater than the effect of electron-electron repulsion. This decreases the size of

the atomic radii and therefore requires more energy to
remove the ¹nd of the [^] least tightly bound electron //

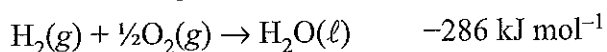


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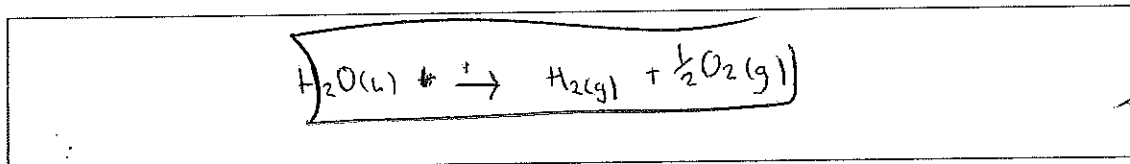
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QUESTION TWO

The equation for $\Delta_f H^\circ$ of $\text{H}_2\text{O}(\ell)$ is:



- (a) (i) Write the equation for $\Delta_c H^\circ$ ($\text{H}_2(\text{g})$).



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

Because they are reverse essentially the same reaction just in ~~opposite~~ order. $\Delta_c H$ is when 1 mol of a substance is completely burnt off i.e. liquid to gas, whereas $\Delta_f H$ is when 1 mol of a substance is formed from its base elements with all reactants and products in their standard states. I.e. ~~water~~ $\text{H}_2\text{O}(\ell)$ formed by $\text{H}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g})$

- (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.

$\Delta_f H^\circ$ ($\text{H}_2\text{O}(\text{g})$) is:

less negative than / the same as / more negative than $\Delta_f H^\circ$ ($\text{H}_2\text{O}(\ell)$).

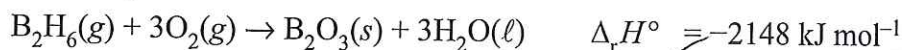
- (ii) Justify your choice.

Because less energy is required to form a gas as the particles are loosely bound together. They are more disordered ~~than~~ producing a lower enthalpy of formation. //

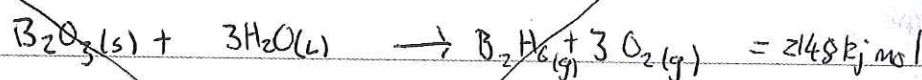
(c) Calculate the $\Delta_f H^\circ$ for $B_2H_6(g)$, given the following data:

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

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



The melting point of boron is 2300°C .



$$\sum (\text{bonds broken}) - \sum (\text{bonds formed})$$

$$= (-1255) + 3(-286) - (2148)$$

$$= -2113 - 2148$$

$$\Delta_f H^\circ B_2H_6(g) = -4261 \text{ kJ mol}^{-1}$$

$$\sum (\text{products}) - \sum (\text{reactants})$$

$$(-1255) + 3(-286) - (-2148)$$

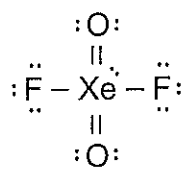
$$\Delta_f H^\circ = -3689 \text{ kJ mol}^{-1}$$

NO

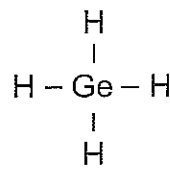
QUESTION THREE

(a) Complete the following table.

	AsF ₅	SeF ₆
Lewis diagram		
Name of shape	trigonal bipyramidal	Octahedral

(b) The Lewis diagrams and shapes for XeO₂F₂ and GeH₄ are shown below.

see-saw



tetrahedral

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

XeO₂F₂ contains 5 electron clouds which predicts a trigonal bipyramidal. 4 bonding 1 non-bonding so actual shape is see-saw. It also contains 2 polar F-Xe bonds and 2 polar Xe=O bonds which create dipoles. ^{due to the electronegativity difference between the atoms} Due to the theory VSEPR ^{theory} It's electron clouds repel as much as possible giving it a see-saw shape however due to the lone pair of electrons its dipoles are not arranged symmetrically around the central atom so overall XeO₂F₂ is non polar.

GeH₄ contains 4 electron clouds which predicts a tetrahedral. Due to the VSEPR theory these electron clouds \wedge as much as possible and because it has 4 bonding 0 non-bonding its actual shape is tetrahedral. It also contains 4 polar

C-O-H bonds due to their electronegativity difference creating dipoles. Because these dipoles are arranged symmetrically around the central atom they cancel out so overall C_2H_6 is non-polar.

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Question Three continues
on the following page.

inter = within
 intra = between

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

Name	Pentan-1-ol	Dimethylpropan-1-ol
Structure	$CH_3-CH_2-CH_2-CH_2-CH_2-OH$	$\begin{array}{c} CH_3 \\ \\ CH_3-C-CH_2-OH \\ \\ CH_3 \end{array}$
Boiling point	138°C	113°C

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

They both contain ~~strong~~ ^{weak} inter molecular forces
 and ~~weak~~ ^{strong} ~~inter~~ ^{intra} molecular forces

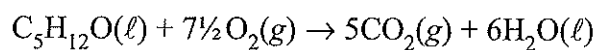
They also contain hydrogen bonding.

Both non polar with permanent dipoles.

- (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.

Pentan-1-ol has a larger boiling point than Dimethylpropan-1-ol due to the effect the dipoles have on the molecule. They both are polar molecules and therefore both contain dipoles, but because Pentan-1-ol has a larger carbon chain these dipoles are further spread out giving it a higher boiling point.

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



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

$$\Delta_f H^\circ (\text{C}_5\text{H}_{12}\text{O}(\ell)) = -295 \text{ kJ mol}^{-1}$$

$$\Delta_f H^\circ (\text{CO}_2(\text{g})) = -394 \text{ kJ mol}^{-1}$$

$$\Delta_f H^\circ (\text{H}_2\text{O}(\ell)) = -286 \text{ kJ mol}^{-1}$$

~~$\Delta_c H^\circ$~~ $\Sigma(\text{products}) - \Sigma(\text{reactants})$

$$= 5(-394) + 6(-286) - (-295)$$

$$= -1970 + -1716 - -295$$

$$\Delta_c H^\circ = -3137 \text{ kJ mol}^{-1}$$

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High Achievement

TOTAL

12

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Achieved Annotated Exemplar Template

Achieved exemplar for 901390 2015		Total score	12
Q	Grade score	Annotation	
1	A4	<p>1a) has given correct electron configurations</p> <p>b) Has not clearly stated that electronegativity is concerned with bonding electrons. Has not given full definition for ionisation energy, missing out the words "1 mole of electrons from an element in its gaseous form".</p> <p>c) Has described in creating protons in the nucleus and linked to increasing nuclear charge, which leads to increased attraction between the nucleus and valence electrons. Has not clearly stated that the same energy level is being filled and so no additional repulsion. States trend in atomic radii.</p>	
2	A3	<p>a) i) Correct equation</p> <p>a) ii) correctly states that it is the same reaction.</p> <p>b) Circles the wrong statement</p> <p>c) Correct calculation</p>	
3	M5	<p>a) Correct structures and names</p> <p>b) Does not discuss the parent geometry, or the reason for taking this shape.</p> <p>c) Has randomly assigned different intermolecular forces to different molecules despite them having the same forces.</p> <p>d) Correct calculation</p>	

QUESTION ONE

(a) Complete the following table.

Symbol	Electron configuration
$_{13}\text{Al}$	$1s^2 2s^2 2p^6 3s^2 3p^1$
$_{29}\text{Cu}^{2+}$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^9$
$_{21}\text{Sc}$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$

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

Electronegativity: *Force of attraction between atoms.*

Force of attraction between the nucleus and electrons.

First ionisation energy: *the first ionisation energy is the energy required to remove the first outermost electron in the valence shell.*

(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}
$_{11}\text{Na}$	502
$_{13}\text{Al}$	584
$_{14}\text{Si}$	793
$_{18}\text{Ar}$	1527

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.

Firstly as you go across a period, the ionisation energy increases, this is because of how as you go across you are adding protons and electrons at the same energy level, increasing the nuclear charge. An

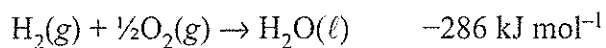
increase in the nuclear charge means there can be a stronger attraction between the nucleus and valence electrons, bringing it in closer. Decreasing the atomic

structure An increase in attraction means it requires even more energy to get one electron out. This explains why the ionisation energy is increasing as you go across the period, as the attraction between nucleus and valence electrons is increasing from Na - Ar. There is a high electronegativity for Ar because of how it's in group 18 noble gases. These elements are very stable and electronegative, so there would be a lot of energy to get one first outermost electron out.

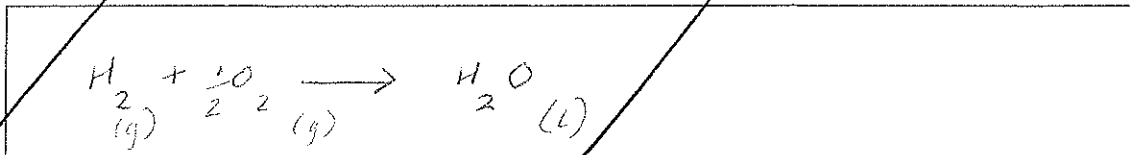
The atomic radius decreases as you go across the period and so the atomic radius decreases in the third period.

QUESTION TWO

The equation for $\Delta_f H^\circ$ of $\text{H}_2\text{O}(\ell)$ is:



- (a) (i) Write the equation for $\Delta_c H^\circ$ ($\text{H}_2(\text{g})$).



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

They have the same value because of how both the equations are the same.

s → l

- (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.

$\Delta_f H^\circ$ ($\text{H}_2\text{O}(\text{g})$) is:

less negative than / the same as / **more negative than** $\Delta_f H^\circ$ ($\text{H}_2\text{O}(\ell)$).

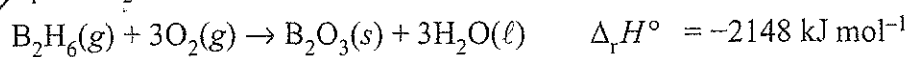
- (ii) Justify your choice.

It takes more energy to form a gas than it does for liquid. As the energy required from solid to gas is little because you're only breaking some bonds however, liquid to gas requires much more energy.

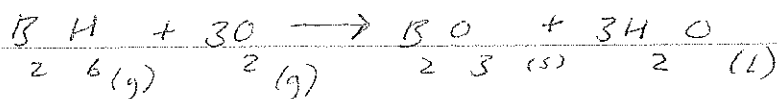
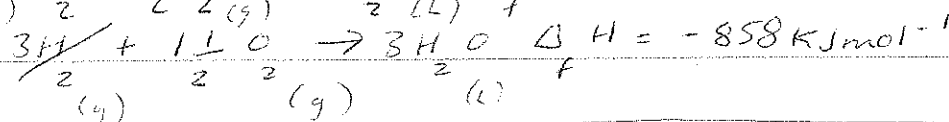
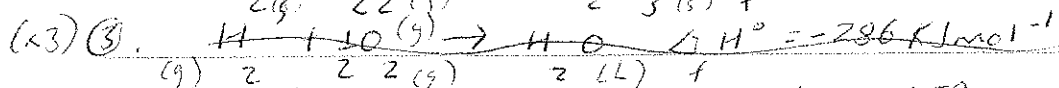
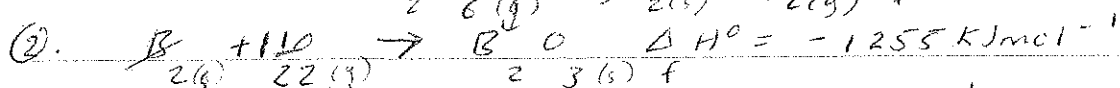
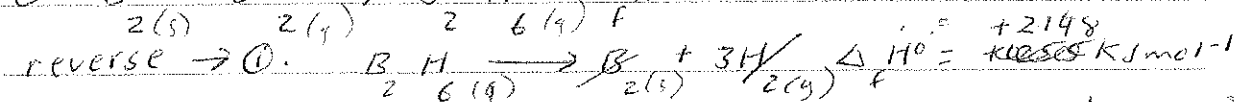
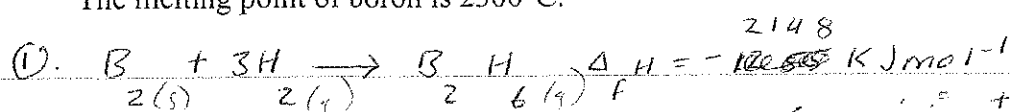
(c) Calculate the $\Delta_f H^\circ$ for $B_2H_6(g)$, given the following data:

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

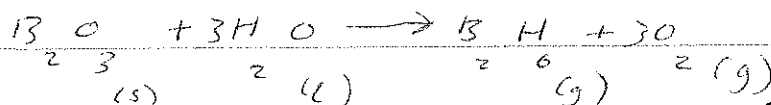
$$\Delta_f H^\circ(H_2O(l)) = -286 \text{ kJ mol}^{-1}$$



The melting point of boron is 2300°C .



$$\Delta H = 35 \text{ kJ mol}^{-1}$$



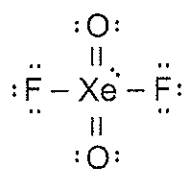
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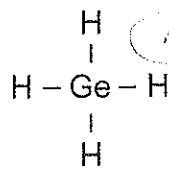
QUESTION THREE

(a) Complete the following table.

	AsF ₅	SeF ₆
Lewis diagram		
Name of shape	trigonal bipyramidal	octahedral

(b) The Lewis diagrams and shapes for XeO₂F₂ and GeH₄ are shown below.

see-saw



tetrahedral

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

XeO₂F₂ - Polarity

- the molecule is polar as the bond dipoles don't cancel and the molecule is not symmetrical. The Xe=O and Xe-F bond is also polar because of the difference in electronegativities.

O and F are more electronegative than Xe.

Shape - the shape is see-saw as the other elements are repelling the lone pair of electrons. There are 5 regions of electron density around Xe the central atom. 4 regions are bonding and there is one lone pair.

GeH₄ - Polarity

the Ge-H bond is polar because of the difference

in electronegativity between Ge and H. The overall molecule is symmetrical and the bond dipoles do cancel making the molecule non-polar.

Shape - the molecule is tetrahedral as the electron repulsions are evenly distributed around. There are 4 regions of electron density and all of them are bonding with Ge the central atom.

Question Three continues
on the following page.

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

Name	Pentan-1-ol	Dimethylpropan-1-ol
Structure	$CH_3-CH_2-CH_2-CH_2-CH_2-OH$	$ \begin{array}{c} CH_3 \\ \\ CH_3-C-CH_2-OH \\ \\ CH_3 \end{array} $
Boiling point	138°C	113°C

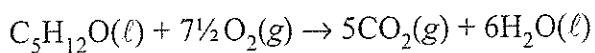
- (i) List all the forces of attraction between these molecules in each of their liquid states.

In both molecules there is hydrogen bonding O-H which is a very strong force of attraction. There is also polar bonds in Pentan-1-ol which means there are permanent dipole forces of attraction. Dimethylpropan-1-ol has some non-polar forces of attraction. So it has some temporary forces of attraction.

- (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.

Both molecules have hydrogen bonding which explains the high boiling points of both molecules. However Pentan-1-ol has polar bonds overall, making it have permanent dipole forces of attraction which are stronger than dimethylpropan-1-ol's non-polar bonds' temporary forces of attraction. It would take more energy to break the bonds between permanent dipole-dipole forces than temporary, instantaneous dipole forces of attractions. Pentan-1-ol also has a larger molar mass than dimethylpropan-1-ol so it would require more energy to break therefore it has a higher boiling point.

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

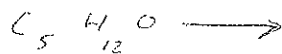
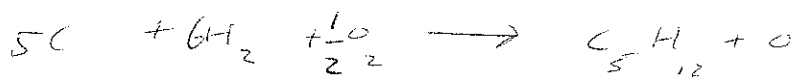
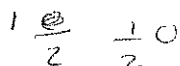
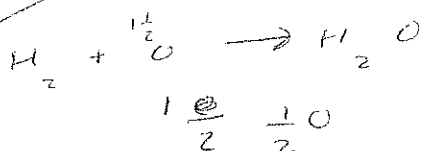
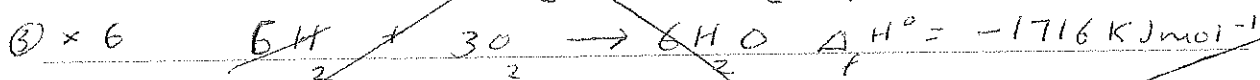
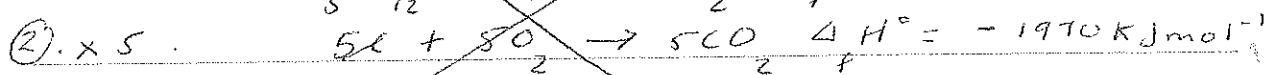
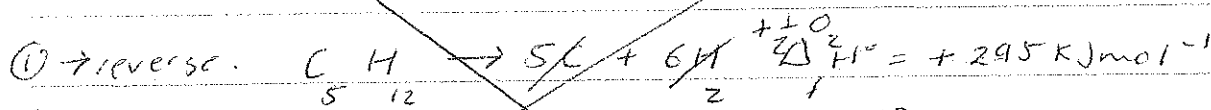
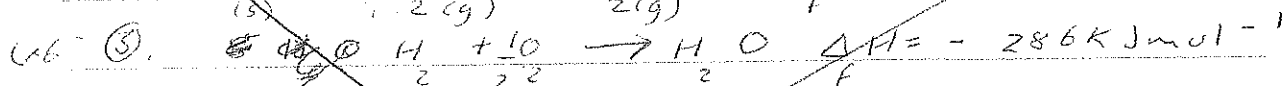
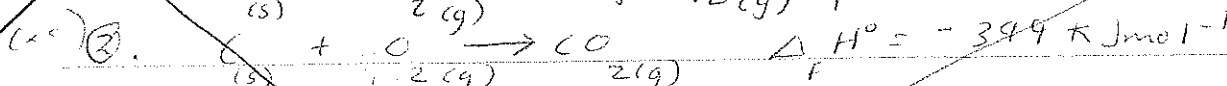
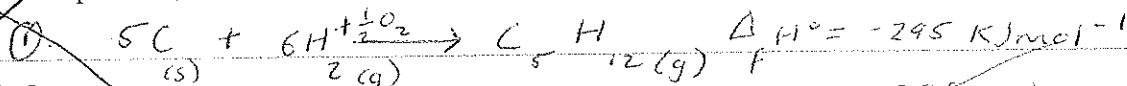


Calculate $\Delta_c H^\circ$ for pentan-1-ol, given the following data:

$$\Delta_f H^\circ (\text{C}_5\text{H}_{12}\text{O}(\ell)) = -295 \text{ kJ mol}^{-1}$$

$$\Delta_f H^\circ (\text{CO}_2(\text{g})) = -394 \text{ kJ mol}^{-1}$$

$$\Delta_f H^\circ (\text{H}_2\text{O}(\ell)) = -286 \text{ kJ mol}^{-1}$$



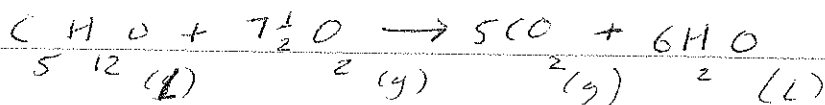
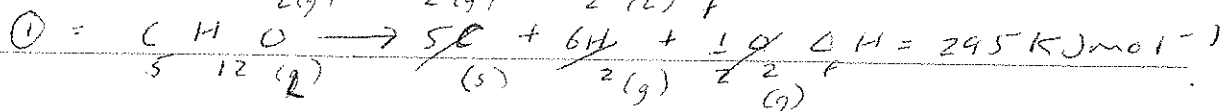
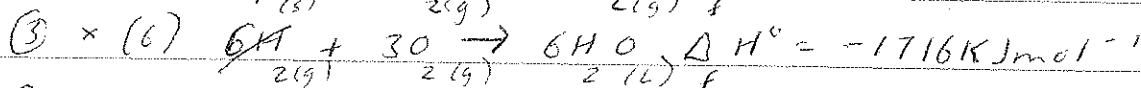
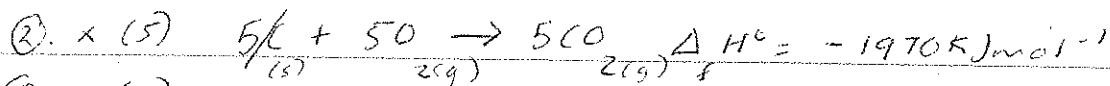
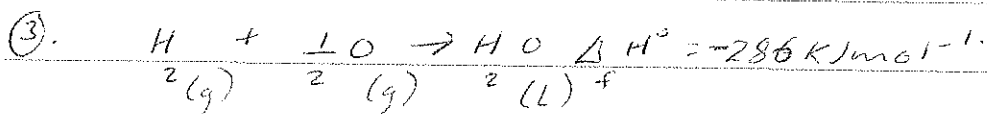
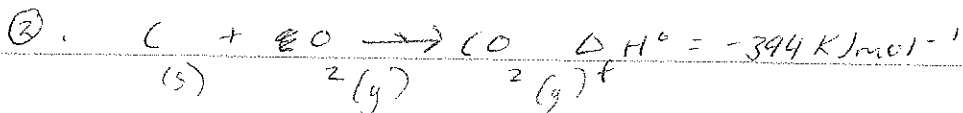
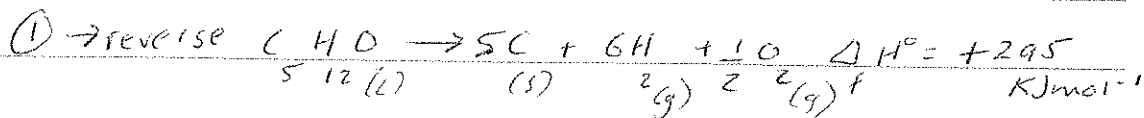
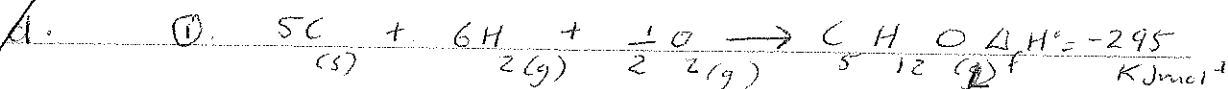
answer
on extra
paper

Extra paper if required.

Write the question number(s) if applicable.

QUESTION
NUMBERASSESS
USE

3



$$\Delta H^\circ = -3391 \text{ kJ mol}^{-1} \quad \text{pentan-1-ol}$$

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913900



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SUPERVISOR'S USE ONLY

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 Achievement

TOTAL

13

ASSESSOR'S USE ONLY

Annotated Exemplar Template



exemplar for 901390 2015		Total score	13
Q	Grade score	Annotation	
1	M5	1a) has given correct electron configurations b) Has one correct definition c) Links increasing nuclear charge to increased electrostatic attraction, but does not link to increasing number of protons. States it is harder to remove and electron, rather than linking to energy. Does not discuss atomic radii.	
2	A3	a) l) Correct equation a) li)correctly states that it is the same reaction. b) Circles the wrong statement c) Correct calculation	
3	M5	a) Correct structures and names b) Correctly discusses electron repulsion, total number of electron areas and parent geometry. States number of bonding and non-bonding pairs and links to the actual shape. Discusses bond polarity and links to electronegativity. States polarity of molecule and links to dipoles cancelling/ not cancelling. c) Hass assigned permanent dipoles to only one molecule and talks about polar bonds of C-H cancelling. d) Correct calculation	

QUESTION ONE

- (a) Complete the following table.

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

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

Electronegativity: the amount of electrostatic attraction a nucleus has to a bonded pair of electrons

First ionisation energy: the amount of energy required to remove 1 mol of ions from 1 mol of atoms to form 1 mol of electrons with a +1 charge

- (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}
Na	502
Al	584
Si	793
Ar	1527

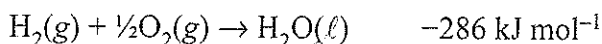
Justify the periodic trend of first ionisation energies shown by the data in the table above, and relate this to the expected trend in atomic radii across the third period.

As all the elements are in the 3rd period they all experience the same amount of shielding (2 energy levels) by the inner electrons. As we go across

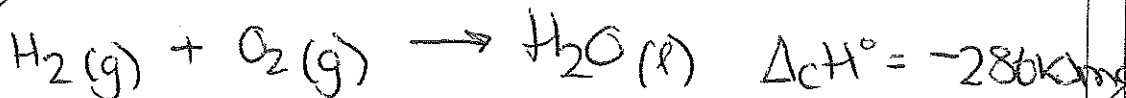
the period from Na to Si there is increasing nuclear charge which results in an increased electrostatic attraction by the positive nucleus to the valence electrons. This as a result means that it is harder to remove electrons from these atoms resulting in increasing 1st ionisation energy values, with Na having the lowest at 502 kJ mol^{-1} due to the least nuclear charge, & increasing through to Si having 793 kJ mol^{-1} due to 3 extra electrons and protons increasing nuclear charge. Ar's significantly higher value is due to Ar being a noble gas, & so therefore having a full energy level resulting in great stability therefore as a result having significantly greater electrostatic attraction to its valence electron so the significantly higher 1st ionisation energy of 1521 kJ mol^{-1} .

QUESTION TWO

The equation for $\Delta_f H^\circ$ of $\text{H}_2\text{O}(\ell)$ is:



- (a) (i) Write the equation for $\Delta_c H^\circ$ ($\text{H}_2(\text{g})$).



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

$\Delta_c H$ and $\Delta_f H$ have the same value of -286 kJ mol^{-1} as the same reaction is occurring in both, resulting in the same energy require to break and reform bonds.

- (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.

$\Delta_f H^\circ$ ($\text{H}_2\text{O}(\text{g})$) is:

less negative than / the same as / **more negative than** $\Delta_f H^\circ$ ($\text{H}_2\text{O}(\ell)$).

- (ii) Justify your choice.

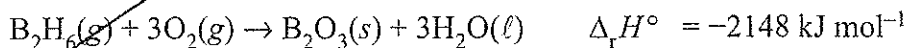
It will be more negative than $\Delta_f H$ of $\text{H}_2\text{O}(\ell)$ as when the bonds of $\text{H}_2(\text{g})$ and $\text{O}_2(\text{g})$ are broken to form both products energy is required however when the bonds are reformed released less energy is required as there is ~~not~~ not additional energy required to form intermolecular forces of

attraction. So the overall reaction will release a greater amount of energy into the surroundings so the $\Delta_f H^\circ(\text{H}_2\text{O}(g))$ will be more negative

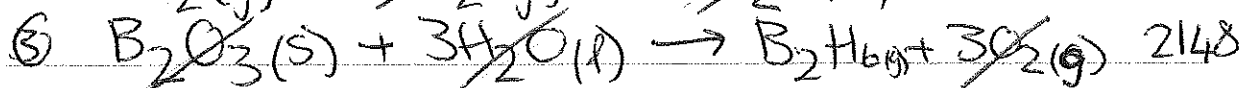
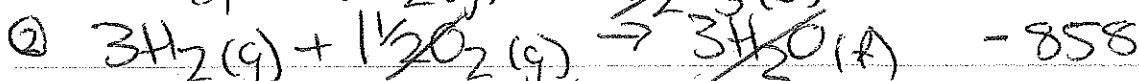
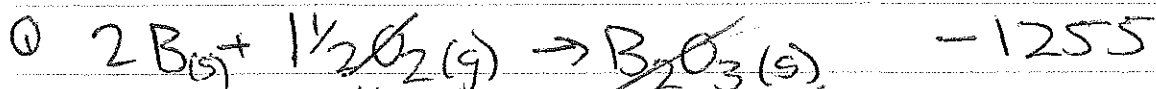
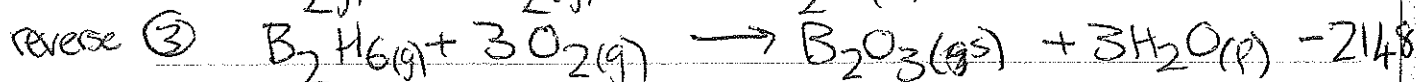
(c) Calculate the $\Delta_f H^\circ$ for $\text{B}_2\text{H}_6(g)$, given the following data:

$$\Delta_f H^\circ(\text{B}_2\text{O}_3(s)) = -1255 \text{ kJ mol}^{-1}$$

$$\Delta_f H^\circ(\text{H}_2\text{O}(l)) = -286 \text{ kJ mol}^{-1}$$



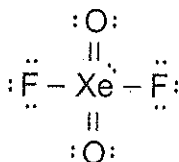
The melting point of boron is 2300°C .



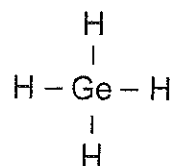
QUESTION THREE

(a) Complete the following table.

	AsF_5 40	SeF_6 48
Lewis diagram		
Name of shape	bipyramid	Octahedral

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

see-saw



tetrahedral

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

There are 5 areas of electron density around the central Xe atom in XeO_2F_2 and 1 lone pair where as there is 4 areas of electron density around the central Ge atom in GeH_4 and no lone pairs. Due to electron-electron repulsion the electron repel each other to a trigonal bipyramid in XeO_2F_2 and tetrahedron in GeH_4 resulting in the shape of seesaw in XeO_2F_2 and tetrahedral in GeH_4 . Since O and F are more electronegative than Xe bond dipoles will form ($\text{O}^{\delta-}-\text{Xe}^{\delta+}$, $\text{F}^{\delta-}-\text{Xe}^{\delta+}$) in XeO_2F_2 and Ge is more electronegative than

($\overset{\delta^-}{\text{Ge}}-\overset{\delta^+}{\text{H}}$) resulting in both molecules contain polar bonds. Since the shape of XeO_2F_2 is seesaw and there is a lone pair the electron density will not be even (asymmetrical) therefore the bond dipoles will not cancel resulting in XeO_2F_2 being polar. However in GeH_4 the shape is tetrahedral with no lone pairs therefore the electron density is symmetrical resulting in the bond dipoles cancelling which results in GeF_4 being non-polar.

Question Three continues
on the following page.

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

Name	Pentan-1-ol	Dimethylpropan-1-ol
Structure	$CH_3-CH_2-CH_2-CH_2-CH_2-OH$ 12 42 50 1d	$\begin{array}{c} CH_3 \\ \\ CH_3-C-CH_2-OH \\ \\ CH_3 \end{array}$ 12
Boiling point	138°C	113°C

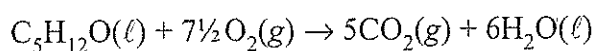
- (i) List all the forces of attraction between these molecules in each of their liquid states.

Both structures have temporary dipole attractions (1d), hydrogen bonding and permanent dipole attractions.

- (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.

Both molecules have the same strength temporary dipole attractions ^{between molecules} due to having the same nuclear charge. They also both have the same strength H-bonding between molecules due to both molecules only containing one O-H bond within their molecule. Pentan-1-ol however has a higher permanent dipole attraction as the 2 of the polar $C^{\delta-}-H^{\delta+}$ bonds cancelling in dimethylpropan-1-ol therefore resulting in pentan-1-ol having a higher boiling point than dimethylpropan-1-ol.

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

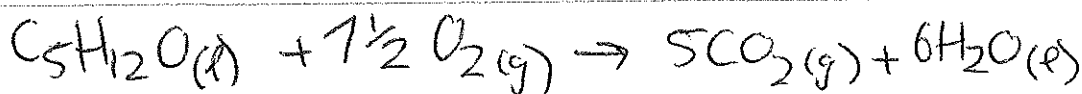
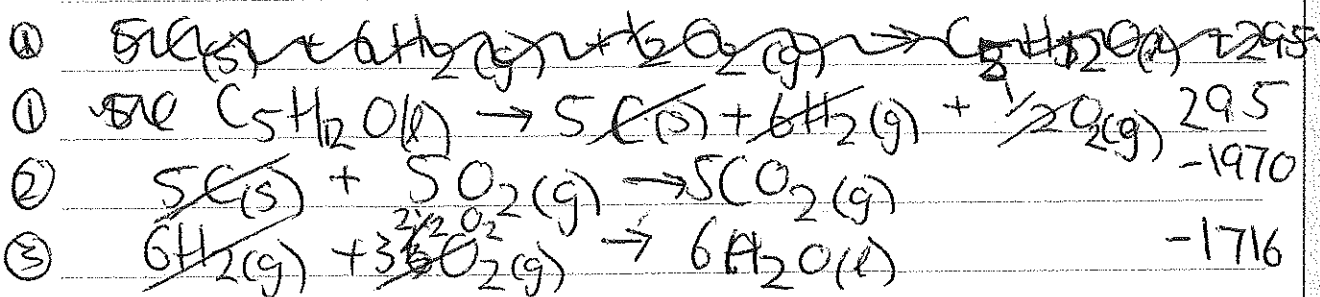
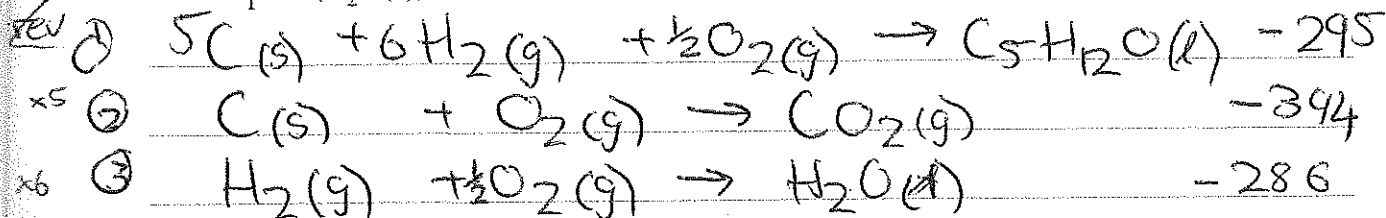


Calculate $\Delta_c H^\circ$ for pentan-1-ol, given the following data:

$$\Delta_f H^\circ (\text{C}_5\text{H}_{12}\text{O}(\ell)) = -295 \text{ kJ mol}^{-1}$$

$$\Delta_f H^\circ (\text{CO}_2(\text{g})) = -394 \text{ kJ mol}^{-1}$$

$$\Delta_f H^\circ (\text{H}_2\text{O}(\ell)) = -286 \text{ kJ mol}^{-1}$$



$$\Delta_c H = -3391 \text{ kJ mol}^{-1}$$