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.

Not Achieved

TOTAL 7

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Achieved Annotated Exemplar Template

<table>
<tr><td colspan="3">Achieved exemplar for 901390 2015</td><td>Total score</td><td>7</td></tr>
<tr><td>Q</td><td>Grade score</td><td colspan="3">Annotation</td></tr>
<tr><td>1</td><td>N2</td><td colspan="3">1a) has not given correct electron configurations
b) Does not define electronegativity, instead describes its trend. Definition of first ionisation energy is confused.
c) Clear description of decreasing atomic radii linked to increasing nuclear charge. Ionisation energy is not discussed and a trend is identified.</td></tr>
<tr><td>2</td><td>N2</td><td colspan="3">a) I) Equation wrong way around.
a) Ii correctly states that it is the same reaction.
b) Circles the wrong statement
c) Mistake in the calculation, but correct procedure.</td></tr>
<tr><td>3</td><td>A3</td><td colspan="3">a) Correct structures and names
b) Talking about polar bonds cancelling, appears to be assigning polarity of the molecule XeO_2F_2 to the lone pair.
c) First statement is neutral as discusses forces holding the molecule together. Also states that pentan-1-ol is a longer chain but does not qualify this by stating that both molecules are the same molar mass. Recognises that the shape is the reason for the increased boiling point, but does not relate to the stronger intermolecular bonding, or the ability to stack closer together.
d) Correct number and units, incorrect sign.</td></tr>
</table>

QUESTION ONE

(a) Complete the following table.

Symbol	Electron configuration
Al 13	$1s^2 2s^2 2p^6$ ~~3s23p1~~ $3p^3$
Cu^{2+} 29-2 27	$1s^2 2s^2 2p^6 3s^2 3p^6$ ~~4s23d10~~ $4s^2 3d^{10}$ 7
Sc 21	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ ~~4p1~~ $3d^1$

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

Electronegativity: the attraction for an atom to bond to a covalent bond. Electronegativity increase across the period and to the top right hand corner of the periodic table and decreases down a group in the periodic table.

First ionisation energy: the energy to make an atom an ion either by removing or bringing electrons into the outter 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}
Na	502
Al	584
Si	793
Ar	1 527

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.

Ionisation energy increases across a period. As seen in the above information all 4 elements are in the same row and increase from the element on the left of that row to the right. This is because as you go across

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a period you are adding more valence shells due to more electrons* This increases the nuclear charge. The nuclear charge is what attracts the valence electrons to the nucleus. Due to the nuclear charge increasing it becomes harder / takes more ionisation energy to remove an electron to make the element become into ion. This is seen in the information given.

* ~~by adding more valence~~ As you go across the period atomic radii decreases as although there are more ~~electrons involved the nuclear charge is~~ also increasing and results in it attracting the valence electrons and the nucleus and pulling it closer together, making the atomic radii decrease.

N2

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QUESTION TWO

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

$H_2(g) + ½O_2(g) \rightarrow H_2O(\ell)$ $\quad -286$ kJ mol^{-1}

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

$H_2O(l) \longrightarrow H_2(g) + \frac{1}{2}O_2(g)$ ~~[illegible]~~

(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}.

combustion involves taking a liquid and making into a gas. The formation of H_2O involves taking 2 gases and making it into a liquid. Therefore ultimately the same thing is occurring with the same amount of heat used in both scenerios

(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.

to make H_2O into the gaseous state you will need a lot more heat energy than just getting it to the liquid state. Therefore it will increase but stay negative due to it being an exothermic reaction.

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

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

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

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

The melting point of boron is 2300°C.

$H_2 + O \longrightarrow H_2O$ -286 KJmol^{-1} $\times 3$

$\frac{1}{2} B_2 + 1\frac{1}{2} O \longrightarrow B_2O_3$ -1255 KJmol^{-1} $\times 2$

$\Delta f H° =$

Σ products $- \Sigma$ reactants

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

$= -1541 - (-2148)$

$= -607$ KJmol^{-1}

N2

linear

trignaol
tetra

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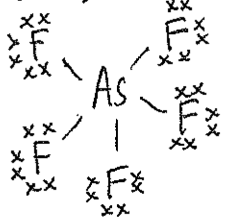
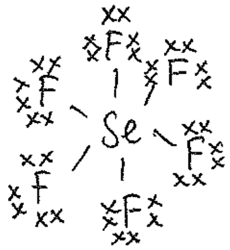
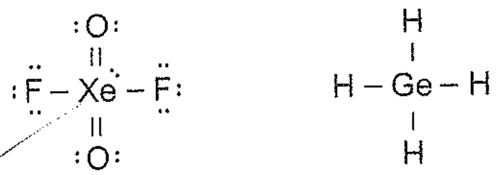
QUESTION THREE

(a) Complete the following table.

	AsF_5	SeF_6
Lewis diagram	$5+(7\times5)=40=20p$ 	$6+(7\times6)=48=24p$ 
Name of shape	trigonal bipyramid	octohedral

U

(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.

XeO_2F_2 has 5 repulsions from the central atom. 2 of these repulsions are the bond of Xe-F, the other two repulsions are the bond of Xe=O and the last one is a lone pair. Due to there being a lone pair the shape could not be triginal bipyramid and is therefore see-saw shape. Both bonds (Xe-F, Xe=O) are polar due to one atom (either F or O) being more electronegative than Xe. The two Xe-F polar bonds cancel each other due to the symmetry of them and the two Xe=O polar bonds also cancel each other out due to the symmetry, although the lone pair can not be cancelled out therefore making the molecule polar overall. The molecule GeH_4 has 4 repulsions around the central atom therefore giving it the tetrahedral shape

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as there are no lone pairs. This molecule also contains 4 polar bonds (Ge–H) as H is more electronegative than Ge. Although as all 4 ~~polar~~ bonds ~~are~~ arranged symmetrically they all cancelk each other out and therefore the molecule is ~~nonepo~~ non-polar.

U

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.

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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.

both molecules have temporary dipoles (weak Van der Waals), permanent dipoles and hydrogen bonding (strongest attraction force)

(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 points is effected by both the forces holding the molecule together and also the shape of the molecule. ~~Both~~ The stronger the forces the higher the boiling point. Although both molecules are held together by the same forces due to both molecules being it therefore must have temporary and permanent dipoles. The both also have hydrogen bonding which is the strongest attraction force. The reason behind pentan-1-ol having a higher boiling point is due to its shape. As pentan-1-ol is a longer chain of carbons it takes more energy (therefore increased boiling point) to overcome the bonds that they are held together by.

(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 $\Delta_cH°$ for pentan-1-ol, given the following data:

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

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

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

$C_5H_{12}O \longrightarrow 12H + 5C + O$ -295 ~~reverse~~

$CO_2 \longrightarrow C + O_2$ -394 (reverse x5)

$H_2O \longrightarrow H_2 + O$ -286 (reverse) x6

+295

+394 x 5

+286 x 6

$\Delta cH° = \cancel{+}3391$ KJmol^{-1} ~~+3928 KJmol^{-1}~~

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A3