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NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

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SUPERVISOR'S USE ONLY

Level 3 Chemistry, 2014

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

2.00 pm Tuesday 11 November 2014
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 space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–10 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.

ACHIEVEMENT

TOTAL 11

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QUESTION ONE

U = understanding (Achievement evidence)
I = in-depth understanding (Merit evidence)
C = comprehensive understanding (Excellence evidence)

(a) Complete the following table.

Symbol	Electron configuration
K 19	$1s^2, 2s^2 2p^6, 3s^2, 3p^6, 4s^1$
Cr 24	[Ar] ~~3d⁵ 4s¹~~ $3d^6$
As 33	$[Ar]\, 3d^{10}, 4d^{10} 4p^3$

Two correct = U

(b) Explain the difference between the radii of the K atom and the K^+ ion.

The K^+ ion has one less electron. Because of this, ~~electron repulsion decreases as electrons all~~ have the same charge and aim for maximum repulsion. The outer most electron energy shell is the 3p shell rather than 4s. since the outer shell is one less energy level away, electron shielding decreases, ~~and~~ this means that the effective nuclear charge on each electron is increased and they are held in tighter.

Electron shielding + effective nuclear charge both need to be explained.

Has linked the loss of an electron to one less shell = U

(c) The following table shows the electron configurations of four atoms, He, B, N, and Ne.

Arrange these atoms in order of increasing first ionisation energy by writing the symbol of the appropriate atom in the boxes below.

Atom	He	B	N	Ne
Electron configuration	$1s^2$	$1s^2 2s^2 2p^1$	$1s^2 2s^2 2p^3$	$1s^2 2s^2 2p^6$

~~Ne~~ B	Ne	He	N
lowest ionisation energy			highest ionisation energy

Incorrect order.

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(d) The halogens make up Group 17 of the periodic table.

(i) The polarity of the HBr molecule is shown below.

$$\overset{\delta+}{H}—\overset{\delta-}{Br}$$

Using this as an example, indicate the polarity of the following bonds by indicating any dipoles present.

Correct polarity = u

1. $\overset{\delta+}{F}—\overset{\delta-}{Cl}$

2. $\overset{\delta+}{At}—\overset{\delta-}{Cl}$

(ii) Using your knowledge of trends in the periodic table, circle the atom below that has the greater electronegativity value.

(Br) I

Justify your answer.

A trend is identified.

Flourine is the most electronegative atom on the periodic table. This means that it holds or attracts electrons more than others. This is ~~because~~ as we go down the group ~~electron shielding~~ increases and so the atoms don't attract electrons as readily. Br is one above I and so it has less energy levels, therefore it will more readily attract electrons than I as ~~electron shielding decreases~~ up the group.

= u

Has identified that less energy levels means greater electronegativity, but fails to mention that valence electrons are therefore closer.

3 × u = A3

QUESTION TWO

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(a) The boiling points of ammonia, NH_3, fluorine, F_2, and hydrogen chloride, HCl, are given in the table below.

Complete the table to identify the attractive forces between the molecules in their liquid state.

Molecule	Boiling point/°C	Attractive forces
Ammonia, NH_3	−33	hydrogen bonds
Fluorine, F_2	−188	temporary dipole attraction
Hydrogen chloride, HCl	−85	permanent dipole

Has identified the main forces = u

(b) Discuss the differences between the boiling points of NH_3 and HCl, in terms of the strength of the attractive forces between the particles involved.

Then describe why F_2 has the lowest boiling point.

NH_3 has the highest boiling point because it has hydrogen bonds which are relatively strong. this hydrogen bond, bonds the N to an H in the NH_3 molecule. this stronger bond takes a relatively high amount of energy to break, henceforth the highest bps & mps.

Incorrectly states that the hydrogen bond is the N-H intramolecular bond.

The F_2 molecule is nonpolar and so its molecules induce temporary dipoles in one another. this is the only bonding force in the molecule :. very low mps & bps as temporary dipoles are very weak.

Again confused about intramolecular bonds.

HCl is a polar molecule, with the Cl being more electronegative. this means that a permanent dipole is created which keeps the molecules bonded. this bond is relatively stronger than temporary dipoles but still weaker than hydrogen bonds.

Recognised the strongest and weakest bond types = u

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(c) An equation for the reaction of ammonia gas with hydrogen chloride gas is:

$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

Calculate the standard enthalpy change, $\Delta_r H°$, for this reaction, using the following data.

$\Delta_f H°\ (NH_3(g)) = -46\ kJ\ mol^{-1}$
$\Delta_f H°\ (HCl(g)) = -92\ kJ\ mol^{-1}$
$\Delta_f H°\ (NH_4Cl(s)) = -314\ kJ\ mol^{-1}$

$\Sigma \Delta_f H°$ products $- \Sigma \Delta_f H°$ reactants

$(-46 + -92) - (-314)$

$-138 + 314$

$= 176$

$\Delta H° = 176\ kJ\ mol^{-1}$

Has confused the products with the reactants.

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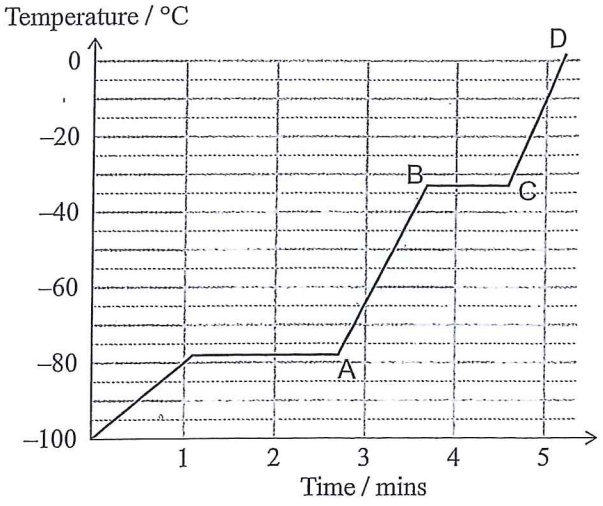
(d) The following graph shows the change in temperature over a five-minute period for a sample of ammonia, where a constant amount of heat was applied per minute.

Heating curve for ammonia



Using the graph above, justify the physical changes occurring to ammonia between points A and D, in terms of the energy of the particles and the intermolecular forces of attraction.

From A-B the ammonia is in its liquid state and the temperature is being absorbed. This temperature is being used to weaken the Hydrogen bonds between the ammonia molecules. Once the temperature reaches -33°c the ammonia(l) can not be heated any more, this is the point where the energy from the temperature change is being used to break the Hydrogen bonds vaporizing the molecule. From C to D temperature continues to rise as the molecules (Now is a gaseous state) are once again absorbing the energy.

From A to D the molecule vaporizes from a liquid to a gas.

heat energy

Correctly links B-C to the breaking of intermolecular bonds = 4

3 × 4 = A3

QUESTION THREE

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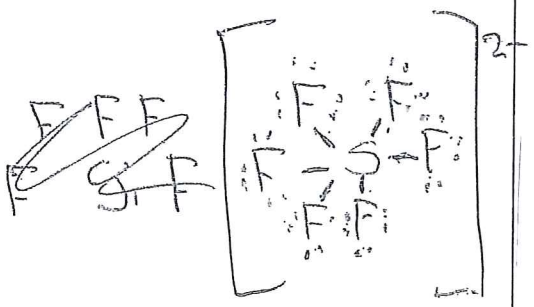
(a) In New Zealand, fluoride for water treatment is supplied as sodium fluorosilicate, Na_2SiF_6.
One of the ions formed in the solution from sodium fluorosilicate is SiF_6^{2-}.

Complete the table below.

	SiF_6^{2-}
Lewis diagram	
Name of shape	Octahedral

Correct, and has remembered to include the charge

Correct shape

= i

(b) Ammonium nitrate is used in 'cold packs' to relieve symptoms of a sports injury. The dissolving of the solid crystals of ammonium nitrate (shown in the equation below) is spontaneous, despite being endothermic.

$$NH_4NO_3(s) \rightarrow NH_4^+(aq) + NO_3^-(aq)$$

Explain why this is so, in terms of the entropy change for the reaction system.

For a reaction to be spontaneous we must take into account not only enthalpy but also entropy. Because 2 mol of product is formed entropy increases. Also because the NH_4NO_3 goes from a solid to a liquid the order or randomness increases and so does its entropy $\Delta H^\circ + \Delta S = G$ so although a reaction is endothermic the entropy + enthalpy may still be greater than 0 therefore making the reaction spontaneous.

Correctly states that entropy increases, plus shows an understanding of what entropy is.

= i

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(c) Ammonium nitrate dissociates in an endothermic reaction, as shown in the equation below.

$$NH_4NO_3(s) \rightarrow NH_3(g) + HNO_3(g)$$

Below is a table outlining four statements about changes in entropy that may occur during any reaction.

Tick (✓) to the left of any statement that is correct for the above reaction.

Tick (✓)	Entropy statement
✓	The entropy of the system increases.
	The entropy of the surroundings increases.
	The entropy of the system decreases.
✓	The entropy of the surroundings decreases.

Correct boxes are ticked.

Justify your choice(s).

The solid sublimes into a gas therefore the ~~force~~ becoming more random and so entropy increases. Also, since there ~~are~~ ~~more~~ moles within the system. This reaction is endothermic and so absorbs energy. This means that energy is being taken from the surroundings and so its entropy decreases.

= i

Clearly understands how entropy is changing in the system, but fails to clarify entropy in the surroundings.

(Not a full justification though)

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(d) (i)

Compound	kJ mol^{-1}
$\Delta_c H°$ (C(*s*))	–394
$\Delta_f H°$ ($H_2O(\ell)$)	–286
$\Delta_c H°$ ($C_2H_5OH(\ell)$)	–1367

Calculate the standard enthalpy of formation of liquid ethanol using the information given above.

~~C_2H_3O~~

C_2H_5OH

No evidence

$\Delta_f H° = 1367 \text{ KJmol}^{-1}$

(ii) Discuss how the value of the enthalpy change would differ if the ethanol product formed was a gas rather than a liquid.

No calculation is necessary.

in a gas, less bonds need do form than in a liquid. therefore, the enthalpy change would be different as formation of a gas requires less energy this means the $\Delta_f H°$ would decrease = u

Correctly states that ΔH is less, but has not said why.

M5