91390

913900

NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

3

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.

MERIT

TOTAL 15

ASSESSOR'S USE ONLY

k p s pd

QUESTION ONE

u = understanding (Achievement)
i = in-depth understanding (Merit)
c = comprehensive understanding (Excellence).

(a) Complete the following table.

Symbol	Electron configuration
K 19	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1$
Cr 24	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^4$ ✗
As 33	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10} 4p^3$

Two correct = u

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

K^+ and K have the same number of protons. However as K^+ has 1 less electron than K there will be less electron repulsion. This results in K^+ having a smaller radii than K.

Shows that the number of protons remains the same. Also shows the relationship between the number of electrons and the amount of electron repulsion. Did not mention that there is a loss of an energy level. = i

(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	$1s^2$	$1s^2 2s^2 2p^1$	$1s^2 2s^2 2p^3$	$1s^2 2s^2 2p^6$

B → N → Ne → He

lowest ionisation energy … highest ionisation energy

Correct order. = u

ASSESSOR'S USE ONLY

(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.

Incorrect.

1. $\overset{\delta^-}{F}—\overset{\delta^-}{Cl}$ non polar

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

(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.

Electronegativity is an element's ability to grab & retain electrons. As you go up & across (right) the periodic table, electronegativity increases. Br & I are both Gr 17 atoms, they both need 1 more electron to fill their valence shell. In Br, the ~~valence~~ ~~4th~~ electron needed will go on the 4th energy level (it is in the 4th period), whereas on I, it will go on the 5th energy level (5th period). Although I has more protons, the electron would be closer to the nucleus in Br than in I, so is less shielded (repelled by the negative electrons), so Br is more electronegative.

Links electronegativity to extra energy level being further away from the nucleus. =

i

2 x u + 2 x i =

A4

(Required 3 x i for M5).

QUESTION TWO

(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	temporgry dipole forces
Hydrogen chloride, HCl	−85	permanent dipole forces

Correct = 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.

• From the three molecules, NH_3 has the highest boiling points due to the strength of the hydrogen bonding between the particles, these bonds require much more energy to break than F_2 and HCl in order for it to boil. Hydrogen bonds are the strongest ~~...~~ form of intermolecular forces. Significant force linked to boiling point for all 3.

HCl has the next highest boiling point because its attractive forces do not require as much energy to break than NH_3 but require more than F_2, its attractive forces are ~~temporary~~ permanent dipole forces which are the second strongest attractive forces out of the three. = i

F_2 has the lowest boiling point out of the three molecules ~~been~~ becouse of the weak temporary dipole forces that hold the particles together, because of this, F_2 has the lowest boiling point, its attactive forces do not require as much energy as NH_3 and HCl to break.

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

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

ASSESSOR'S USE ONLY

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

$\Delta_r H° = \sum \Delta_f H°$ of products $- \sum \Delta_f H°$ of reactants.
$= -314 - (-46 + -92)$
$= -176$ kJ

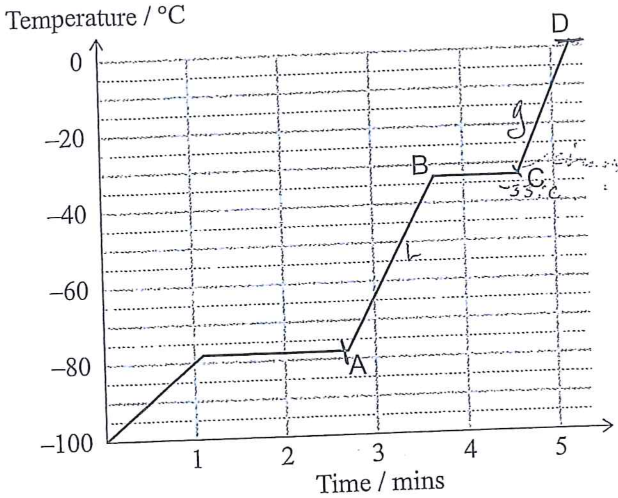
Correct process and answer, but incorrect unit. = u.

ASSESSOR USE ONLY

(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.

NH_3

Heating curve for ammonia



H-bonding.

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.

NH_3 has hydrogen bonding. between points A and B, the ammonia is a liquid, its temperature is steadily increasing. Between points B and C NH_3 has reached its boiling point and is changing state from liquid to gas. C to D is when the ~~steam~~ ammonia is steam.

~~Between B and C, where NH_3 has reached its boiling point,~~

As the ammonia is heating energy is being put in. Since the ammonia is changing state the particles are getting more excited, they are gaining energy.

= u.

Needed to relate the increase in temperature to the gain of kinetic energy in sections A→B and C→D. Also needed to state that intermolecular bonds are broken in section B→C.

3×u + i =

(2i = M5).

A4

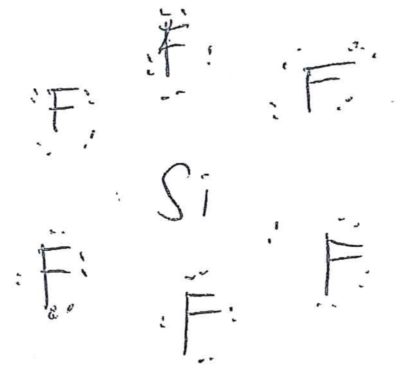
ASSESSOR'S USE ONLY

QUESTION THREE

(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-} 4+42+2=48
Lewis diagram	
Name of shape	Octahedral

No charge or square brackets.

= u.

Correct shape

(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.

Entropy is the amount of disorder ~~or~~, randomness or how ordered a substance can be. $NH_4NO_3(s)$ is a solid which its entropy will be very ~~high~~ low as particles within the substance is in a fixed position and fully restrained from movement. However the ions produced in the reaction are in aqueous solution and therefore have very high entropy levels with high disorder. Because particles are much more free ~~and~~ to move around therefore the increase in entropy is the driving force of the reaction. Because of this the reaction is spontaneous.

= i

Has clearly stated what entropy is and linked this to the question.

ASSESSOR'S USE ONLY

(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.

Justify your choice(s).

• The entropy of the system increases as it is an endothermic reaction which indicates it is gaining heat energy

• The entropy of the surroundings decreases as the reaction is endothermic which indicates that the surroundings lose heat energy.

Has not indicated that they understand what entropy is.

Has recognised that entropy changes, but has not link the changes to losing or gaining energy.

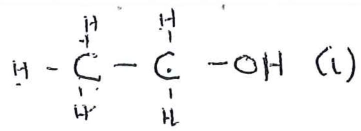
= u.

ASSESSOR'S USE ONLY

(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

$\Delta f H°$ =



$\Delta_f H°$ = $2C + 3H_2 + \frac{1}{2}O_2 \longrightarrow C_2H_5OH(l)$

Calculate the standard enthalpy of formation of liquid ethanol using the information given above. $2C + 3H_2 + \frac{1}{2}O_2 \longrightarrow C_2H_5OH(l)$

$\Delta_c H°(C(s))$ = ~~$C(s) + O_2 \longrightarrow CO_2$ = –394 kJmol^{-1}~~ [x2

$\Delta_f H(H_2O(l))$ = ~~$H_2 + \frac{1}{2}O_2 \longrightarrow H_2O(l)$ = –286 kJmol^{-1}~~ [x3

$\Delta_c H°(C_2H_5OH(l))$: ~~$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$ = 1367 kJmol^{-1}~~ [reverse

~~$3H_2O + 2CO_2$~~ $\longrightarrow$ $C_2H_5OH(l)$ ~~$3O_2$~~ = 1367 kJmol^{-1}

$3H_2 + \frac{1}{2}O_2 \longrightarrow$ ~~$3H_2O(l)$~~ = –858 kJmol^{-1}

$2C(s) + 2O_2 \longrightarrow$ ~~$2CO_2$~~ = –788 kJmol^{-1}

1367 kJmol^{-1} + –858 kJmol^{-1} + –788 kJmol^{-1} = –279 kJmol^{-1}

$\Delta f H°$ of Liquid ethanol = Correct process leading to

–279 kJmol^{-1} an accurate answer with units. = C

(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.

ΔH° would be greater if it had formed as a gas as more energy would be required to ~~change~~ form 1 mol of gaseous ethanol. (to form a gas more energy is needed (higher/BP).

Takes more ~~energy~~ enthalpy to change a gas than it does a liquid ~~as a gas has~~

A higher amount of energy is needed to ~~break~~ ~~liquid~~ change Liquid → gas than solid → gas. = i

Δsublimation = greater than H°Δ Fusion ~~Vaporisation~~.

1 x c =

E7