3

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91390

913900

NZQA

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Level 3 Chemistry, 2017

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

2.00 p.m. Wednesday 15 November 2017
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.

Excellence

TOTAL 21

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QUESTION ONE

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(a) Complete the following table.

Symbol of particle	Electron configuration (use *s, p, d* notation)	Charge	Atomic number
Cl	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$	0	17
Ca^{2+}	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$	+2	20
Mn^{2+}	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3$	2+	25

18
23

(b) (i) Define the term electronegativity.

Electronegativity is the level of attraction of a given atom for bonding electrons

(ii) Explain why the electronegativity of chlorine is greater than that of phosphorus.

The electronegativity of chlorine is greater than that of phosphorus. Both chlorine and phosphorus have the same energy level, thus the same amount of shielding. However Chlorine has more protons (greater nuclear charge) and electrons as compared to phosphorus. This means that there is stronger electrostatic attraction between the nucleus and valence electrons of chlorine than phosphorus, thus making chlorine more electronegative than phosphorus.

(c) The following graph shows the first ionisation energies of the Group 2 elements from Be to Ba.

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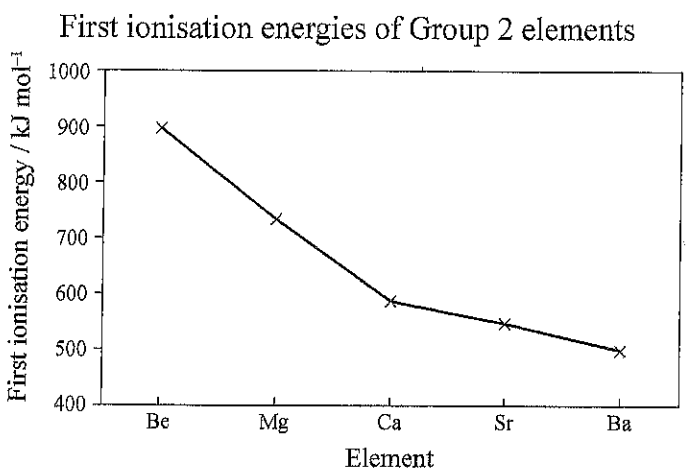

(i) Write an equation to show the first ionisation energy for the element calcium.

$Ca_{(g)} \longrightarrow Ca^{+}_{(g)} + e^-$

(ii) Explain the trend shown of first ionisation energies of the Group 2 elements.

Ionisation energy is the energy required to remove one mole of electrons from one mole of ions or atoms in gaseous state. The ionisation energies in group 2 decreases down the group from ~~Be to Be~~ Be (around 900 KJmol^{-1}) to Ba (around 500 KJmol^{-1}). This is because the ~~the~~ outer energy levels increase down the group so the distance between the nucleus and and valence electrons increase, thus the amount of shielding also increase. This means there is weaker attraction between nucleus and valence electrons (as further ~~apart~~ away and more shielded) making ~~Mg~~ ~~Ca, Sr, Ba weak~~ the atom less tightly held together down a group so less energy is required to remove an electron. This means, it is harder to remove an electron from Be (more tightly held together due to less shielding and less main board of outer energy levels, A stronger attraction between nucleus and valence electrons) than it is for Ba. Despite nuclear charge increasing (more protons) down a ~~group~~ group (which increases attraction between nucleus and valence electrons) this is outweighed by the increased ~~distance~~ outer energy level and shielding which is more significant compared to nuclear charge increasing.

E8

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QUESTION TWO

Molecule	Boiling Point / °C	M / g mol^{-1}
Hydrazine, N_2H_4	114	32
Iodomethane, CH_3I	42.4	142
Decane, $C_{10}H_{22}$	174	142

Use the information in the table above to compare and contrast the boiling points of the substances below.

In your answers, you should:

- list the types of intermolecular forces present for each substance
- explain the relative strength between the particles involved.

(a) (i) Hydrazine and iodomethane.

In hydrazine, there is the ~~nuclear~~ intermolecular forces of temporary dipole-dipole, permanent dipoles and hydrogen bonding as compared to iodomethane which has only temporary dipole-dipole and permanent dipole-dipole. ~~Despite~~ Hydrazine having hydrogen bonding which is the strong intermolecular forces of attraction ~~is there lower boiling point~~ due to N-H bond makes Hydrazines have a higher boiling point than Iodomethane. As Iodomethane only has temporary ~~temporary~~ dipole-dipole and permanent dipole which are weaker intermolecular forces of attraction so are held less tightly together as compared to N_2H_4 resulting in lower boiling point of 114. Despite having a larger molar mass for CH_3I, the hydrogen bonding in N_2H_4 is more significant than large molar mass so higher boiling point for N_2H_4.

(ii) Iodomethane and decane.

Decane has a higher boiling point of 174°C than Iodomethane of 42.4°C. Decane has temporary dipole-dipole which Iodomethane also has, but Iodomethane not ~~has~~ only has temporary ~~than~~ dipole-dipole, but also permanent dipole-dipole (stronger intermolecular force than temporary dipole-dipole). ~~They~~ Both have the same molar mass. Despite Iodomethane having stronger ~~forces~~ intermolecular forces of attraction, decane has a higher boiling point. This is due to decane being a very large molecule as compared to Iodomethane. The more decanes decane has more decapers which means stronger temporary dipole/dipole so more energy is required to break the forces of decane than it is for Iodomethane.

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(b) Explain why the solubility of hydrazine in water is greater than that of decane in water.

Solubility of hydrazine in water is greater than decane in water. This is because hydrazine is a polar molecule and water is a polar molecule so the attractive forces between the hydrazine and water can be overcome resulting in hydrazine dissolving in water. (due to difference in electronegativity between N & H.)

However for decane, it is a non-polar molecule so it does not dissolve in water because the attractive forces between water and decane cannot be overcome, thus the intermolecular forces of decane is not dissolve

(c) Carbon dioxide and water are formed when decane burns completely in oxygen. The reaction is shown in the equation below.

$$C_{10}H_{22}(\ell) + 15\tfrac{1}{2}O_2(g) \rightarrow 10CO_2(g) + 11H_2O(\ell)$$

Calculate the enthalpy of combustion for decane, given the following data:

$\Delta_f H^\circ$ ($C_{10}H_{22}(\ell)$) = –301 kJ mol^{-1}

$\Delta_c H^\circ$ (C) = –393 kJ mol^{-1}

$\Delta_c H^\circ$ (H_2) = –286 kJ mol^{-1}

$C_{10}H_{22(l)} + 15\,1/2\,O_{2(g)} \rightarrow 10CO_{2(g)} + 11H_2O_{(l)}$

$10C_{(s)} + 11H_{2(g)} \rightarrow C_{10}H_{22(l)} = -301\ kJ\,mol^{-1}$

$= -3930_{kJmol} \times 10 \quad (C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} = -393\ kJ\,mol^{-1})$

$= -3146_{kJmol} \times 11 \quad (H_{2(g)} + \tfrac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)} = -286\ kJ\,mol^{-1})$

$\Delta cH^\circ =$

$\Delta H\ C_{10}H_{22(l)} + 15\,1/2\,O_{2(g)} \rightarrow 10CO_{2(g)} + 11H_2O_{(l)} : \Delta cH^\circ =$

$(\Sigma \Delta H \text{ products}) - (\Sigma \Delta H \text{ reactants})$

$\Delta cH^\circ = (-3930 + -3146) - (-301)$

$= -6775\ kJ\,mol^{-1}$

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(d) The reaction for the complete combustion of hydrazine is shown in the equation below.

$$N_2H_4(\ell) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$$

This is an exothermic reaction.

Explain the entropy changes associated with this reaction.

This is an exothermic reaction so entropy of surrounding increase, so energy is released to produce $N_2(g)$ and $H_2O(g)$. The entropy of the system also increase because of the amount of gaseous particles that have created, there from 1 to 3 mol. This means particles are more spread out and random and less ordered so an entropy of system increases. Overall this means the complete combustion of hydrazine is a spontaneous reaction.

E8

QUESTION THREE

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Chlorine, Cl_2, bromine, Br_2, and iodine, I_2, are all halogens.
Bromine is a liquid at room temperature.

(a) (i) In the box below, tick the type(s) of intermolecular attractions in **liquid** bromine.

Intermolecular attraction	**Tick (✔)**
Temporary dipole-dipole attractions	✓
Permanent dipole-dipole attractions	
Hydrogen bonding	

(ii) Explain why bromine is a liquid at room temperature, whereas chlorine is a gas.

(b) (i) Write an equation for the sublimation of iodine in the box below.

$I_{2(s)} \longrightarrow I_{2(g)}$

(ii) Define the enthalpy of sublimation for iodine.

Enthalpy of sublimation means energy required to break the forces in the convert one mole of solid iodine to gas

Question Three continues on the following page.

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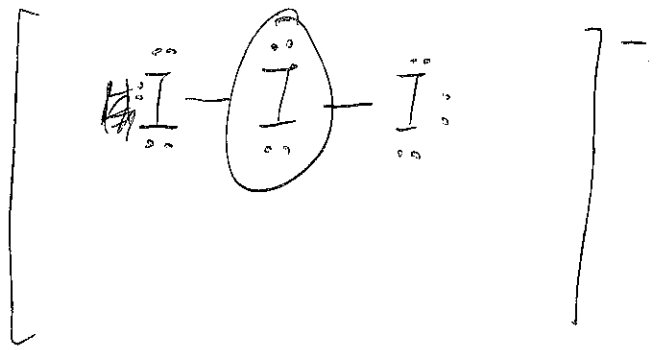
(iii) Explain why the sublimation of iodine is spontaneous, even though the enthalpy of sublimation is a positive value.

Sublimation of iodine is spontaneous because ~~sublim~~ this converts a the solid to a gas which means there is ~~more random~~ gaseous particles spread out which increases the entropy of the system. This is more significant than the +ve positive value indicating it is a endothermic reaction, thus is a spontaneous reaction ✓

(c) Iodine forms a linear I_3^- ion.

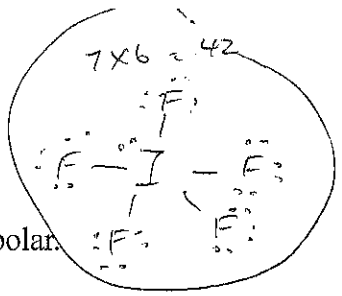
(i) Draw the Lewis structure for the I_3^- ion in the box below.

7x3 + 1 = 22



(ii) Explain why the I_3^- ion has a linear shape.

I_3^- has a linear shape because there are 4 electron density regions around the central atom I which arrange with maximum separation to minimise $e^- - e^-$ repulsion give a base shape of tetrahedral. As there are 2 bonding and 2 non bonding regions, the the actual shape is linear ✓



(iii) IF_5 has a square pyramidal shape.

Indicate whether the molecule IF_5 is polar or non-polar.

Circle your choice. **polar** **non-polar**

Justify your choice.

IF5 The bonds in IF5, I–F are polar due to a difference in electronegativity between the I and F (F more electronegative) which results in dipoles for each bond. These dipoles are arranged in a nonsymmetrical square pyramidal shape (due to 5 bonding and one non bonding regions of IF5) the dipoles due not cancel out, resulting in an overall dipole. This means IF5 is polar. IF5 as 6 regions of electron density around central atom I which are arranged with maximum seperation to minimise ere repulsion giving octahedral base shape but because 5 are bonding and (non bonding shape is square pyramidal, a non symmetrical shape as explained below

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MS

Excellence exemplar 2017

Subject:	Chemistry	Standard:	91390	Total score:	21

Q	Grade score	Annotation
1	E8	The candidate clearly understands the factors that affect electronegativity and ionisation energy. They are also able to distinguish which factors are most important to determine trends.
2	E8	The candidate has a thorough understanding of intermolecular forces and can evaluate each molecule to compare their strengths. They can also calculate enthalpy accurately using correct units. Their entropy answer was not at excellence level as they did not link the increase in entropy of the surroundings to an increase kinetic energy of particles.
3	M5	This candidate was unable to compare intermolecular attraction differences for bromine and chlorine. Their answer for the sublimation of iodine's spontaneity was not specific enough to demonstrate understanding of the opposing nature of the enthalpy and entropy of this reaction. Their answer for the polarity of IF_5 was at excellence level.