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.

Merit

TOTAL 15

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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	17 $1s^2 2s^2 2p^6 3s^2 3p^5$	0	17
Ca^{2+}	$1s^2 2s^2 2p^6 3s^2 3p^6$	+2	20
Mn^{2+}	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$	+2	25

(b) (i) Define the term electronegativity.

electronegativity is a measure of an atom's nucleis ability to attract electrons.

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

Cl and P are in the same period. Cl is further right in the table. Cl and P have the same amount of shells therefore the distance between nuclei and electrons is similar. Cl however has a stronger nuclear charge as it has more protons to attract the electrons. Even though, Cl has more electron-electron repulsion the strength of the nuclear charge is significantly stronger. Thus the attraction between nuclei and electrons is stronger which means, the electronegativity is greater.

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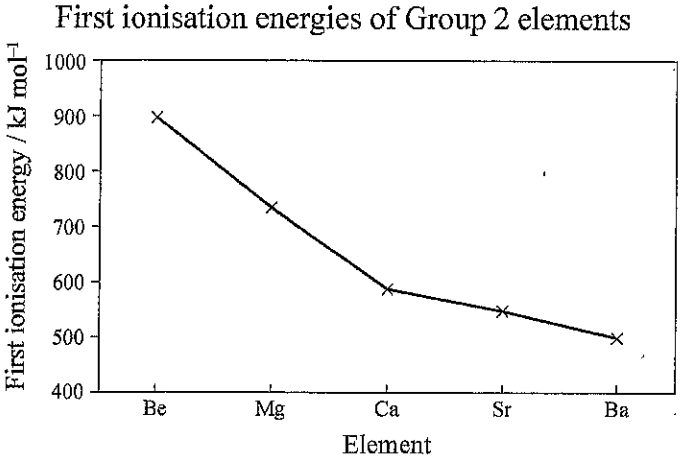
(c) The following graph shows the first ionisation energies of the Group 2 elements from Be to Ba.



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

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

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

The ionisation energy of group 2 decreases as you travel down the group. This is because as you travel down the group the size of the molecule increases as the shells are added. Be has the highest 1st ionisation energy because the attraction between its nucleas and most loosely bonded electron is quite strong. Moving down 1 to Mg, we add another electron shell. This increases the electron - electron repulsion and the shielding effect. Therefore the attractive force between the nuclei and the electron requires less energy to be broken compared to Be. Moving further down to Ca another shell is added and thus there is more repulsion between electrons. Although the nuclear charge increases the shielding effect has more impact on the 1st ionisation energy. So again even less energy is required to remove the least bound electron. This trend is also seen through Sr and Ba.

M6

QUESTION TWO

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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 are temporary dipole ~~forces~~ forces and Hydrogen bonding whereas, iodomethane has temporary dipole forces and permanent dipole forces. Hydrogen bonding is the strongest intermolecular force and thus requires more energy to break this can be seen in the higher boiling point. Iodomethane has a relatively low Boiling point as the strength of permanent dipole forces aren't as strong and therefore do not require as much energy to break. ✓

(ii) Iodomethane and decane.

~~Hydrazine~~ Iodomethane ~~only~~ has temporary dipole forces & permanent dipole forces as it is a polar molecule. Decane only has temporary dipole forces. Decane however has the higher boiling point due to its ~~name~~ longer chain length. ~~arrangement~~ The longer chain means there are more forces to break Eventhough the forces are weaker theres more of them, thus, requiring a lot more energy. Iodomethane has a small chain therefore less energy ~~and~~ is required to break less of ~~does~~ its stronger forces. //

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

Decane is a non-polar molecule that is a very long chain. Decane is more attracted to itself than water as water is a polar molecule. Hydrazine has hydrogen bonding ~~within between~~ Thus it is more attracted to water than decane is making it more soluble in water.

(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}

$C + O_2 \rightarrow CO_2 \quad \Delta_c H = -393$

$H_2 + \frac{1}{2}O_2 \rightarrow H_2O \quad \Delta_c H = -286$

$11H_2 + 5C_2 \rightarrow C_{10}H_{22} \quad \Delta_f H = -301$

$C_{10}H_{22} \rightarrow 11H_2 + 5C_2 \quad \Delta_f H = 301$

$10 \times (C + O_2 \rightarrow CO_2) \quad \Delta_c H = 10 \times -393 = -3930$

$11 \times (H_2 + \frac{1}{2}O_2 \rightarrow H_2O) \quad \Delta_c H = 11 \times -286 = -3146$

$\Delta_c H (C_{10}H_{22}) = 301 + -3930 + -3146$

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

(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.

$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$ is an exothermic reaction because the bonds in $N_2H_4(l)$ are breaking to react and form $N_2(g)$ and $2H_2O(g)$. During this reaction the entropy increases as there is more disorder amoung the particles. There are 2 ~~reactants~~ molecules to form 3 molecules therefore there is more chaos. Additionally, the liquid N_2H_4 becomes two gases which has a lot more disorder as gases don't have intermolecular forces holding them together.

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M5

Bigger Stronger nuclear charge

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QUESTION THREE

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.

Both Cl_2 and Br_2 have only temporary dipole forces between the molecules. ~~Br has a stronger nuclear charge so~~ Br_2 will have stronger intermolecular forces than Cl_2 because of its stronger nuclear charge. Cl_2's intermolecular forces can be broken at room temp because room temp provides the sufficient amount of energy. But it doesn't provide sufficient energy to break Br_2's forces. ✓

(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.

The energy required to change 1 mol of $I_{2(s)}$ into $I_{2(g)}$ ✓

Question Three continues on the following page.

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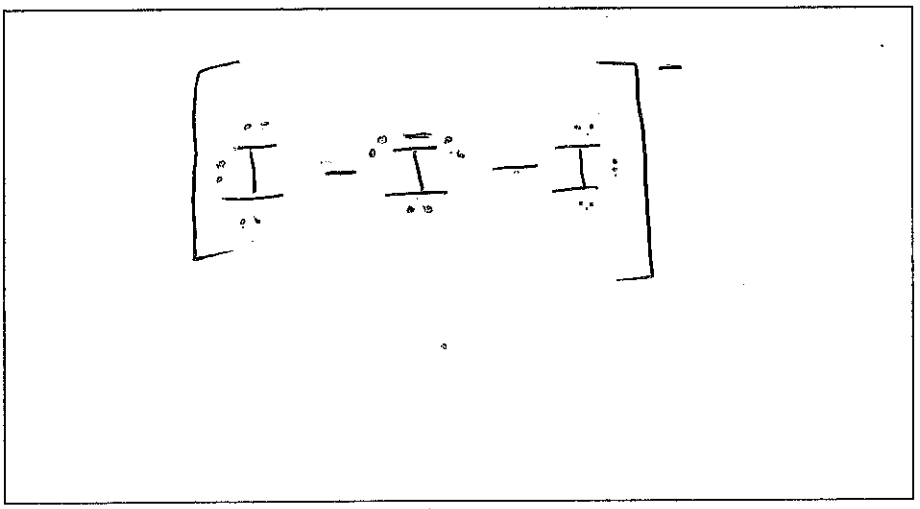
(iii) Explain why the sublimation of iodine is spontaneous, even though the enthalpy of sublimation is a positive value.

$\Delta_{sub}H(I_2)$ = + value therefore it requires energy to break bonds to form a gas. $I_{2(s)} \rightarrow I_{2(g)}$ can be spontaneous if the enthalpy value is very small so that room temperature could supply this amount of energy. Thus the reaction although requiring heat to complete can happen almost anywhere if the surroundings can supply the energy needed.

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

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



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

I_3^- has 5 electron clouds surrounding the central I. atom. This makes the shape trigonal bipyramidal due to valence shell electron pair repel. Because I_3^- is linear rather than bent because this is how the valence electrons decrease the amount of repulsion.

(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.

IF_5 has 6 electron clouds surrounding the central I atom. Due to Valence Shell Electron pairs repulsion IF_5 has an ~~acted~~ octahedral shape. However, only 5 of the 6 electron clouds are bonded, leaving one non-bonding. Because of this IF_5 has a molecular shape of square pyramid. ~~The~~ The I - F bond has a dipole. $I^{\delta+} - F^{\delta-}$ due to the difference in electronegativity. As IF_5 ~~is~~ shape of molecule in not symetrical, the effect of the dipole ~~does~~ is unable to cancel. Therefore IF_5 is polar.

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A4

Merit exemplar 2017

Subject:	Chemistry	Standard:	91390	Total score:	15

Q	Grade score	Annotation
1	M6	The candidate understands the factors that affect electronegativity and ionisation energy. However in order to get an excellence level answer for electronegativity, the candidate needs to show understanding that electronegativity involves the attraction of bonding electrons in order to form a bond. In order to earn excellence for ionisation energy, the candidate should recognise that moving down a group increases shielding due to more electron shells, but there is not more electron-electron repulsion within a shell.
2	M5	The candidate shows some understanding of intermolecular forces. However, they needed to recognise that even though iodomethane is a much larger molecule with more temporary dipole attractions, hydrazine requires more energy due to the strength of the hydrogen bonds. They also needed to realise that although decane has the same molar mass, there are far more electrons therefore far more temporary dipole attractions. Solubility in water is best explained with reference to the strength of attractions between the solvent and solute. The entropy of the reaction requires an explanation of entropy changes in both the system and surroundings in order to be at excellence level.
3	A4	The candidate needed to refer to the larger molar mass with more electrons, and hence stronger temporary dipole attractions of bromine compared to chlorine. The spontaneity of the reaction of iodine needs reference to the idea that the increase in entropy of the reaction offsets the decrease in enthalpy despite the latter not being favoured. In order to improve the answer for the polarity of IF_5, there needs to be an explanation of why the molecule is not symmetrical.