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SUPERVISOR'S USE ONLY

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.

Achievement

TOTAL 12

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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	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1$	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

(b) (i) Define the term electronegativity.

Electronegativity is the elements attraction for electrons. Force to valance shell electrons ✓

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

Chlorine and Phosphorus are both in period 3. This means they have both have 3 electron shells. However Cl has 17 protons while P only has 15. Therefore Cl has more protons and the effective nucleer charge between the nucleas and valence shell electrons is greater. Thus Cl has a higher electronegativity ✓

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

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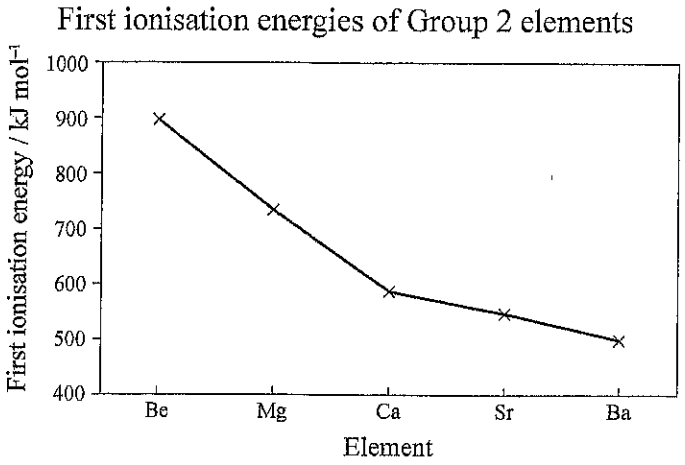

(i) Write an equation to show the first ionisation energy for the element calcium.

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

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

As you go down group 2 you gain an extra electron shell each time. The shielding force from the electron shell gaining is greater than the added protons effective nuclear charge. Therefore the energy required to remove ~~the outer most~~ one valence electron is less as it is easier to remove it. Thus the ionisation energy required to remove the one valence shell electron decreases as you go down group 2.

M5

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.

Iodomethane has ~~no~~ temporary dipoles as its intermolecular forces. Hydrazine has temporary dipoles, permanent dipoles and hydrogen bonding for intermolecular forces. Temporary dipoles are very weak and thus even though CH_3I has a large molar mass it has a low boiling point as the energy required to break the bonds is minimal. Hydrogen bonding are the strongest form of intermolecular forces and thus it requires the most energy to break these bonds meaning N_2H_4 has a high boiling point.

(ii) Iodomethane and decane.

Decane ~~has~~ and Iodomethane have the same molar mass. However, Decane has temporary and permanent dipoles while CH_3I just has temporary dipoles. ~~This~~ the Permanent dipoles are much stronger than temporary dipoles meaning that they require more energy to break than temporary. Thus the boiling point of $C_{10}H_{22}$ is much higher than CH_3I.

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

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Solubility is determined by strength of the H_2O bonds vs the intermolecular forces of the solute. As N_2H_4 has hydrogen bonds (strongest permanent dipoles) it has the strongest intermolecular forces as the hydrogens become protons which then link onto the N_2H_4 molecules. decane has weaker permanent dipoles. ~~and thus~~ As N_2H_4 has stronger intermolecular forces ~~bonds~~ it is more likely to overcome the H_2O intermolecular forces (Hydrogen bonding) and thus dissolve into H_2O.

(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}

$\Delta fH\ C_{10}H_{22}$

$C_{10} + 11H_2 + O_2 \rightarrow C_{10}H_{22} + O_2$

ΔcH° ~~C_{10}~~ $C_{10}H_{22}$ $+ O_2 \rightarrow$

~~ΔfH~~ $\Delta cH\ C + O_2 \rightarrow CO_2$

$\Delta cH\ 2H_2 + O_2 \rightarrow 2H_2O$

$\Delta cH^\circ\ H_2 = 11H_2 + 5\,1/2\ O_2 \rightarrow 11H_2O = 11 \times -286$

$\Delta cH^\circ\ C = 10C + \frac{10}{2}O_2 \rightarrow 10\ CO_2 = 10 \times -393$

ΔcH° ~~$C_{10}H_{22}$~~ $C_{10}H_{22} = C_{10}H_{22} +$ ~~O_2~~ $\rightarrow C_{10} + 11H_{22} = 301$

$11 \times -286 + 10 \times -393 + 301$

$= -6775$ 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.

* Entropy is the disorder in a system.

The liquid and the gas has changed to 3 gas moles. This is an increase in entropy of the system as not only have bonds been broken, there is also an increase in the amount of gaseous moles. As there is an increase in entropy in the system there is a decrease in entropy of the surroundings. This reaction will be spontaneous as $\Delta G = \Delta_r H - T\Delta S$ and $\Delta_r H$ is negative as the reaction is exothermic and ΔS is positive, thus it also will subtract giving you a negative ΔG (Gibbs free energy) and thus making it a spontaneous reaction.

A3

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.

Bromine is a much larger atom than Chlorine. Thus it takes a lot more energy to break the bonds between the ~~solid~~ liquid and ~~liquid~~ gaseous state. Therefore bromine has a ~~melting~~ boiling point than chlorine and it is a liquid at room temperature while chlorine is a gas. ✓

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

$I_2(s) \xrightarrow{\text{sublimation}} I_2(g)$

(ii) Define the enthalpy of sublimation for iodine.

The energy required to change ~~the~~ 1 mole of I_2 from the ~~gaseous~~ solid state to the gaseous state. ✓

Question Three continues on the following page.

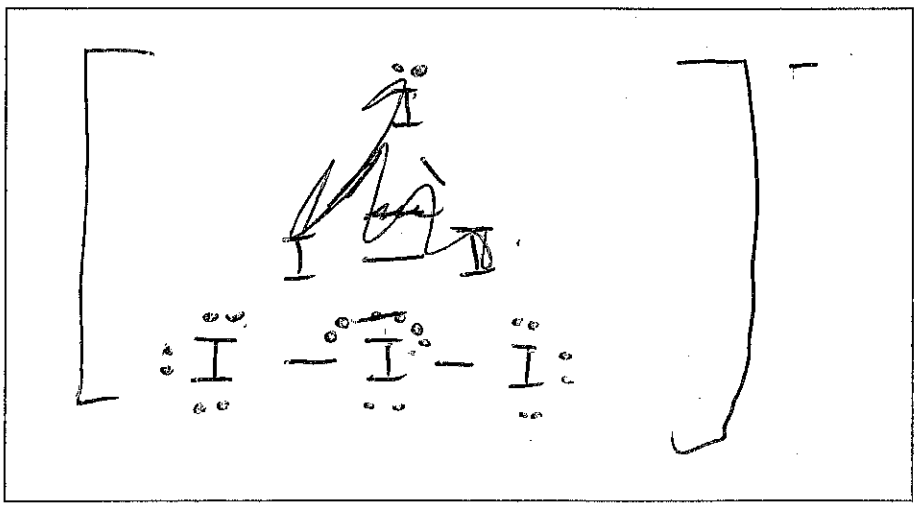
$\Delta G = \Delta_r H - TS$

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

As I_2 is going from a solid to a gas, the increase in entropy in the system is very large. This increase in entropy is larger than the endothermic positive enthalpy and using the equation $\Delta G = \Delta_r H - \Delta S T$ we can see if ΔS is greater than $\Delta_r H$ then ΔG will be negative and the reaction will be spontaneous.

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

(i) Draw the Lewis structure for the I_3^- ion in the box below. 22 e^-



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

As 2 out of the 5 electron clouds are bonded. Thus the bond angles are 180° as VSEPR states that they must be as far away as possible from other which is 180° and thus gives I_3^- a linear shape.

(iii) IF_5 has a square pyramidal shape.

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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 ~~and~~ of which 5 of them are bonded. Due to VSEPR (valence shell electron pair repulsion) theory these will as far away as possible from each other. This gives IF_5 the square pyramidal shape. ~~Due to~~ F ~~being~~ is more electronegative than I. This means electrons will spend more time around F than I as it attracts electrons more. This results in a slightly negative charge δ^- on the F atoms and a slightly positive charge δ^+ on the I atoms. Due to this we have polar dipoles created. As the square pyramidal shape is not symmetrical the polar dipoles will not cancel and thus IF_5 is ~~indeed~~ indeed polar ✓

A4

Achievement exemplar 2017

Subject:	Chemistry	Standard:	91390	Total score:	12

Q	Grade score	Annotation
1	M5	In order to achieve excellence level answers, the candidate needs to acknowledge that both elements being in the third period means the same shielding effect. They also need to explain that as you go down a group, there are more protons in the nucleus, increasing nuclear charge but this is outweighed by the increasing distance between the nucleus and outer shell electrons.
2	A3	There is some understanding of intermolecular forces but the candidate needs to be able to identify the correct forces for more than one molecule as well as compare the molecules in each example in order to demonstrate sufficient understanding. It is important to be very explicit about intermolecular forces versus forces within a molecule and ensure that solubility is understood.
3	A4	The candidate could have referred to bromine as a molecule to demonstrate understanding of what occurs when a molecule changes state. It is important to link statements regarding the increase of entropy to what is happening to the particles for the change in entropy. When describing a shape, it is expected that the geometry of the molecule as well as the shape is communicated.