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NZQA

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Level 3 Chemistry, 2019

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

2.00 p.m. Thursday 14 November 2019
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 and relevant formulae are provided in the Resource Booklet 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 2–12 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.

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QUESTION ONE

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(a) Complete the following table.

Symbol	Electron configuration (use *s, p, d* notation)
Cr	
Fe^{3+}	
Ge	

(b) Complete the following table.

	SF_4	SF_3^-
Lewis structure		
Name of shape		

(c) (i) Explain why the radii of the S atom and the S^{2-} ion are different.

	Radius / pm
S atom	104
S^{2-} ion	184

(ii) Justify the difference in electronegativities for oxygen, sodium, and sulfur.

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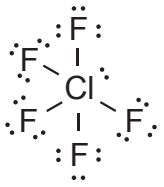
Element	Electronegativity
Oxygen, O	3.44
Sodium, Na	0.93
Sulfur, S	2.58

(d) The Lewis structure of ClF_5 is given below.



Identify and explain the shape and polarity of ClF_5.

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QUESTION TWO

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(a) The equation for the vaporisation of hexane is:

$$C_6H_{14}(\ell) \rightarrow C_6H_{14}(g)$$

Circle the term that best describes this process:

Exothermic **Endothermic**

Give a reason for your choice.

(b) The equation for the formation of liquid hexane is:

$$6C(s) + 7H_2(g) \rightarrow C_6H_{14}(\ell)$$

Calculate the standard enthalpy of formation for liquid hexane, $\Delta_f H°(C_6H_{14}(\ell))$, using the following data:

$$C_6H_{14}(\ell) + 9.5O_2(g) \rightarrow 6CO_2(g) + 7H_2O(\ell)$$

$\Delta_c H°(C_6H_{14}(\ell)) = -4163$ kJ mol^{-1}
$\Delta_c H°(C(s)) = -394$ kJ mol^{-1}
$\Delta_c H°(H_2(g)) = -286$ kJ mol^{-1}

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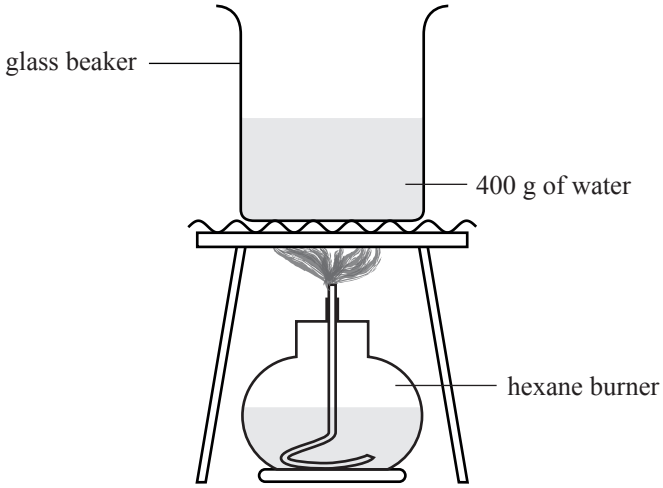
(c) The enthalpy of combustion of liquid hexane, $\Delta_c H(C_6H_{14}(\ell))$, can be determined by burning a known mass of hexane and measuring the temperature change in a known mass of water above the burning hexane.

(i) If 5.22 g of hexane is burned, the temperature of 400 g of water increases from 20.5°C to 36.7°C.

Using these results, calculate an experimental value of $\Delta_c H(C_6H_{14}(\ell))$.

The specific heat capacity of water is 4.18 J g^{-1} $°C^{-1}$.

$M(C_6H_{14})$ = 86.0 g mol^{-1}



(ii) Explain why the experimental value obtained in part (c)(i) is less negative than the theoretical value of -4163 kJ mol^{-1}, given in part (b).

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QUESTION THREE

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(a) List all the forces of attraction between the following molecules in their liquid state.

Molecule	Boiling point / °C	Attractive forces
Ammonia, $NH_3(\ell)$	–33.3	
Ethane, $C_2H_6(\ell)$	–88.6	
Methanamine, $CH_3NH_2(\ell)$	–6.3	

(b) (i) Using the data in the above table, identify the molecule that has the strongest forces of attraction between its molecules.

(ii) Justify why methanamine has a higher boiling point than ethane.

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(iii) Justify why methanamine has a higher boiling point than ammonia.

(c) Ammonia, NH_3, reacts with methane, CH_4, in the following reaction:

$$CH_4(g) + NH_3(g) \rightarrow HCN(g) + 3H_2(g)$$

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

$\Delta_f H°(NH_3(g))$ = –45.9 kJ mol^{-1}
$\Delta_f H°(CH_4(g))$ = –74.9 kJ mol^{-1}
$\Delta_f H°(HCN(g))$ = +135 kJ mol^{-1}

Question Three continues on the following page.

(d) Ammonia reacts with oxygen according to the equation below.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g) \qquad \Delta_r H^\circ = -906 \text{ kJ mol}^{-1}$$

Justify, in terms of the entropy changes of the system and surroundings, why the reaction is spontaneous.

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Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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