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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Chemistry 2024

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

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 other reference material 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.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (▨). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

QUESTION ONE

(a) Complete the table below.

	PF_5	$SeCl_4^{2-}$
Lewis structure		
Shape		

(b) (i) The reaction between chlorine trifluoride, $ClF_3(g)$, and hydrazine, $N_2H_4(\ell)$, is explosive. It was investigated as a potential rocket fuel. The reaction is shown below.

$$4ClF_3(g) + 3N_2H_4(\ell) \rightarrow 12HF(g) + 3N_2(g) + 2Cl_2(g)$$

Calculate $\Delta_r H°$ for the reaction, given the following data.

$N_2H_4(\ell) + O_2(g) \rightarrow N_2(g) + 2H_2O(\ell)$	$\Delta_r H° = -623$ kJ mol^{-1}
$2ClF_3(g) + 2NH_3(g) \rightarrow 6HF(g) + N_2(g) + Cl_2(g)$	$\Delta_r H° = -1200$ kJ mol^{-1}
$4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(g)$	$\Delta_r H° = -1270$ kJ mol^{-1}
$H_2O(\ell) \rightarrow H_2O(g)$	$\Delta_{vap} H° = 40.7$ kJ mol^{-1}

(ii) Justify, in terms of the entropy changes of the system and the surroundings, why the reaction between chlorine trifluoride and hydrazine is spontaneous.

$$4ClF_3(g) + 3N_2H_4(\ell) \rightarrow 12HF(g) + 3N_2(g) + 2Cl_2(g)$$

QUESTION TWO

(a) (i) The table below gives the electron configurations of three elements.

Argon, Ar	Neon, Ne	Phosphorus, P
$1s^2 2s^2 2p^6 3s^2 \mathbf{3p^6}$	$1s^2 2s^2 2p^6$	$1s^2 2s^2 2p^6 3s^2 3p^3$

When considering the $3p^6$ part of the electron configuration of argon, what is represented by the following?

3 _____

p _____

6 _____

(ii) Arrange the three elements Ar, Ne, and P, in order of decreasing first ionisation energy.

Use your knowledge of periodic trends to justify your order.

[ ] > [ ] > [ ]

(b) The two possible shapes of bromine trichloride, $BrCl_3$, are T-shaped and trigonal planar. Both of these shapes are based on the trigonal bipyramidal arrangement of electron pairs around the central atom.

Research shows that the $BrCl_3$ molecule is polar.

Compare the two possible shapes of the $BrCl_3$ molecule to identify which shape would result in the $BrCl_3$ molecule being polar.

Your answer should refer to bond polarity and the arrangement of the bond dipoles.

QUESTION THREE

(a) (i) Identify all the types of attractive forces between particles of the following substances in their liquid state in the table below.

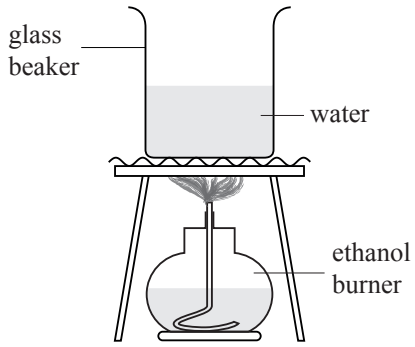
Substance	Boiling point / ºC	Attractive forces
Ammonia, NH_3	–33	
Sulfur dioxide, SO_2	–10	
Pentane, $CH_3CH_2CH_2CH_2CH_3$	36	

(ii) Explain the difference in the boiling points of ammonia and sulfur dioxide.

(iii) Explain why the boiling point of pentane is higher than that of sulfur dioxide.

Question Three continues on the next page.

(b) The enthalpy of combustion of ethanol, C_2H_5OH, was determined experimentally using the apparatus below. The ethanol was completely combusted to heat some water in a beaker.



The following data was recorded:

- initial water temperature = 22.1 °C
- final water temperature = 31.2 °C
- initial mass of burner and ethanol = 59.2 g
- final mass of burner and ethanol = 58.7 g

The student calculated the experimental enthalpy change for the combustion of liquid ethanol, $\Delta_c H(C_2H_5OH(\ell))$, to be –770 kJ mol^{-1}.

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

$M(C_2H_5OH)$ = 46.0 g mol^{-1}

(i) Use the information provided to calculate the mass of the water that was in the beaker.

(ii) Which of these quantities calculated would have been a source of error in the calculated enthalpy value?

Circle your answer.

temperature change of water **mass of fuel combusted**

Explain your choice.

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

QUESTION NUMBER

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

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