

91390



Draw a cross through the box (X) if you have NOT written in this booklet

+



Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Chemistry 2025

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 the margins (✂✂✂). 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.

Sulfur forms a range of different fluoride-containing ions and molecules.

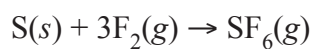
	SF_3^-	SBrF_5
Lewis structure		
Name of shape		

$$\begin{array}{c} \text{:}\ddot{\text{F}}\text{:} \\ | \\ \text{:}\ddot{\text{F}}-\text{S}-\ddot{\text{F}}\text{:} \\ | \\ \text{:}\ddot{\text{F}}\text{:} \end{array}$$

seesaw

- (ii) Justify why the F-S-F bond angles in SF₄ are different to the F-S-F bond angles in SBrF₅.

- (c) Finely powdered sulfur, $S(s)$, readily reacts with fluorine gas, $F_2(g)$, in an exothermic reaction to produce sulfur hexafluoride, $SF_6(g)$. The equation for the reaction is:



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

QUESTION TWO

- (a) (i) Complete the table below.

Symbol	Electron configuration (use <i>s</i> , <i>p</i> , <i>d</i> notation)
Cl	
Cu	
Fe ³⁺	

- (ii) Iron, Fe, can form two different ions, Fe²⁺ and Fe³⁺. Their ionic radii are given below:

Fe²⁺ 92 pm

Fe³⁺ 79 pm

Explain why the radius of the Fe²⁺ ion is larger than the radius of the Fe³⁺ ion.

- (b) (i) Identify all the types of attractive forces between particles of the following substances in their liquid state.

Substance	$\Delta_{\text{vap}}H^\circ / \text{kJ mol}^{-1}$	Attractive forces
Hydrogen bromide, HBr(<i>ℓ</i>)	17.3	
Hydrogen fluoride, HF(<i>ℓ</i>)	25.2	
Bromine, Br ₂ (<i>ℓ</i>)	29.6	

- (ii) Explain why the $\Delta_{\text{vap}} H^\circ$ of HF is higher than that of HBr.

- (iii) Justify why Br_2 has the highest $\Delta_{\text{vap}}H^\circ$ of the three substances.

- $$4\text{CH}_3\text{NHNH}_2(\ell) + 5\text{N}_2\text{O}_4(\ell) \rightarrow 4\text{CO}_2(\text{g}) + 12\text{H}_2\text{O}(\text{g}) + 9\text{N}_2(\text{g})$$

- $$\text{C(s)} + 3\text{H}_2\text{(g)} + \text{N}_2\text{(g)} \rightarrow \text{CH}_3\text{NHNH}_2\text{(l)} \quad \Delta_r H^\circ = +54.1 \text{ kJ mol}^{-1}$$



- (ii) Explain the effect on the standard enthalpy change calculated in part (c)(i) if the water was produced as a liquid.

QUESTION THREE

- (a) Nitric acid, HNO_3 , is manufactured from ammonia, NH_3 . The equation for one of the reactions in the process is:



- (i) Write the balanced equation to represent the standard enthalpy of formation of ammonia in the table below.

Substance	Equation	$\Delta_f H^\circ \text{ kJ mol}^{-1}$
$\text{NH}_3(\text{g})$		
$\text{NO}(\text{g})$	$\frac{1}{2} \text{N}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{NO}(\text{g})$	+90.3
$\text{H}_2\text{O}(\ell)$	$\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\ell)$	-286

- (ii) Calculate the standard enthalpy of formation for ammonia, $\Delta_f H^\circ(\text{NH}_3(\text{g}))$, using the data given in part (i).

- | Period 3 element | Na | Mg | Al | Si | P |
|------------------|-------|-------|-------|-------|-------|
| Atomic radius/nm | 0.191 | 0.160 | 0.130 | 0.118 | 0.110 |

- $$\text{CaCl}_2(s) \rightarrow \text{Ca}^{2+}(aq) + 2\text{Cl}^{-}(aq) \quad \Delta H = -81.3 \text{ kJ mol}^{-1}$$

Assume the mass of the calcium chloride solution is 68.0 g.

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

QUESTION
NUMBER

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

QUESTION
NUMBER

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

QUESTION
NUMBER

91390