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91390





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.

#### **QUESTION ONE**

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

(a) Complete the table below:

	SF <sub>3</sub> <sup>-</sup>	SBrF <sub>5</sub>
Lewis structure		
Name of shape		

(b) The Lewis structure and shape for sulfur tetrafluoride,  $SF_4$ , are shown below.

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Ide	entify and explain the polarity of SF <sub>4</sub> .

	$S(s) + Sr_2(g)$	$\rightarrow Sr_6(g)$	
s of the entropy cha	anges of the syste	m and surroundin	gs, why the reaction is
	hexafluoride, SF <sub>6</sub> (g	hexafluoride, $SF_6(g)$ . The equation for $S(s) + 3F_2(g)$	ed sulfur, $S(s)$ , readily reacts with fluorine gas, $F_2(g)$ , the hexafluoride, $SF_6(g)$ . The equation for the reaction is: $S(s) + 3F_2(g) \rightarrow SF_6(g)$ so of the entropy changes of the system and surrounding

#### **QUESTION TWO**

(a) (i) Complete the table below.

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

(ii) Iron, Fe, can form two different ions, Fe<sup>2+</sup> and Fe<sup>3+</sup>. Their ionic radii are given below:

Fe<sup>2+</sup> 92 pm

Fe<sup>3+</sup> 79 pm

Explain why the radius of the  $Fe^{2+}$  ion is larger than the radius of the  $Fe^{3+}$  ion.

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

Substance	$\Delta_{ m vap} H^{ m o}/{ m kJ~mol^{-1}}$	Attractive forces
Hydrogen bromide, $\mathrm{HBr}(\ell)$	17.3	
Hydrogen fluoride, $\mathrm{HF}(\ell)$	25.2	
Bromine, $\operatorname{Br}_2(\ell)$	29.6	

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Justify why Br <sub>2</sub> h	as the highes	st $\Delta_{\mathrm{vap}}H^{\circ}$ of	f the three su	lbstances.	

(c)	Dinitrogen tetroxide, N <sub>2</sub> O <sub>4</sub> ,	was reacted with methylhydrazine,	CH <sub>3</sub> NHNH <sub>2</sub> .	The equation for
	the reaction is:			

$$4\mathrm{CH_3NHNH_2}(\ell) + 5\mathrm{N_2O_4}(\ell) \rightarrow 4\mathrm{CO_2}(g) + 12\mathrm{H_2O}(g) + 9\mathrm{N_2}(g)$$

(i) Calculate the standard enthalpy change of this reaction, using the following data.

$C(s) + 3H_2(g) + N_2(g) \rightarrow CH_3NHNH_2(\ell)$	$\Delta_{\rm r} H^{\circ} = +54.1 \text{ kJ mol}^{-1}$
$C(s) + O_2(g) \rightarrow CO_2(g)$	$\Delta_{\rm r} H^{\circ} = -394 \text{ kJ mol}^{-1}$
$\mathrm{N_2}(g) + 2\mathrm{O_2}(g) \to \mathrm{N_2O_4}(\ell)$	$\Delta_{\rm r} H^{\circ} = -20.0 \text{ kJ mol}^{-1}$
$H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(\ell)$	$\Delta_{\rm r} H^{\circ} = -286 \text{ kJ mol}^{-1}$
$H_{\bullet}O(\ell) \rightarrow H_{\bullet}O(g)$	$\Lambda H^{\circ} = +40.7 \text{ kJ mol}^{-1}$

(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<sub>3</sub>, is manufactured from ammonia, NH<sub>3</sub>. The equation for one of the reactions in the process is:

$$4\mathrm{NH_3}(g) + 5\mathrm{O_2}(g) \rightarrow 4\mathrm{NO}(g) + 6\mathrm{H_2O}(\ell) \qquad \qquad \Delta_{\mathrm{r}}H^{\circ} = -1172 \; \mathrm{kJ} \; \mathrm{mol}^{-1}$$

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

Substance	Equation	$\Delta_{ m f} H^{\circ}  { m kJ \ mol^{-1}}$
NH <sub>3</sub> (g)		
NO(g)	$\frac{1}{2} N_2(g) + \frac{1}{2} O_2(g) \rightarrow NO(g)$	+90.3
$\mathrm{H_2O}(\ell)$	$H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(\ell)$	-286

(i)	Justify, using your knowledge of periodic trends, why magnesium, Mg, has a greater fi ionisation energy than strontium, Sr.						
(ii)	The atomic radii of five	elements fro	m Period 3 ar	e shown in the	e table below.		
(ii)	The atomic radii of five of Period 3 element	elements from	m Period 3 ard	e shown in the	e table below.	P	
(ii)						P 0.110	
(ii)	Period 3 element	Na 0.191	Mg 0.160	A1 0.130	Si		
(ii)	Period 3 element Atomic radius/nm	Na 0.191	Mg 0.160	A1 0.130	Si		
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	n solid calcium chloride, $CaCl_2(s)$ , dissolves in water, the temperature increases from $^{\circ}C$ to 23.2 $^{\circ}C$ .
	$CaCl_2(s) \to Ca^{2+}(aq) + 2Cl^{-}(aq)$ $\Delta H = -81.3 \text{ kJ mol}^{-1}$
Calcı	alate the mass of $CaCl_2(s)$ that must dissolve to cause this temperature increase.
	<del>-</del>
Assu	me the specific heat capacity of the calcium chloride solution is $4.18 \text{ J g}^{-1} ^{\circ}\text{C}^{-1}$ .
Assu	me the mass of the calcium chloride solution is 68.0 g.
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