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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Chemistry 2023

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 (DO NOT WRITE IN THIS AREA DO NOT WRITE). This area will be cut off when the booklet is marked.

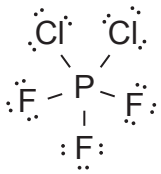
YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

QUESTION ONE

(a) Complete the table below.

	SF_4	SF_6
Lewis Structure		
Shape		

(b) The Lewis structure for phosphorus trifluorodichloride, PF_3Cl_2, is shown by:



Identify and explain the shape and polarity of PF_3Cl_2.

(c) (i) Write the equation that represents the enthalpy of vaporisation, $\Delta_{vap}H°$, for hydrazine, N_2H_4.

(ii) Explain whether the process in part (i) is exothermic or endothermic.

(iii) The reaction shown below of hydrazine reacting with oxygen is exothermic.

$$N_2H_4(\ell) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$$

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

QUESTION TWO

(a) (i) Write the equation to show the reaction that has an enthalpy change equal to the first ionisation energy for the element gallium, Ga.

(ii) Use your knowledge of periodic trends to identify and justify the difference in the first ionisation energy of gallium, Ga, and selenium, Se.

(iii) Use your knowledge of periodic trends to explain why gallium, Ga, has a larger atomic radius than boron, B.

(b) (i) The equation below shows the reaction of ammonia, $NH_3(g)$, with carbon dioxide, $CO_2(g)$, to produce urea, $CO(NH_2)_2(s)$.

$$2NH_3(g) + CO_2(g) \rightarrow CO(NH_2)_2(s) + H_2O(g) \qquad \Delta_r H^\circ = -89.0 \text{ kJ mol}^{-1}$$

Calculate the standard enthalpy of formation of urea, $\Delta_f H^\circ(CO(NH_2)_2(s))$, using the following data.

$\Delta_f H^\circ(NH_3(g)) = -46.0 \text{ kJ mol}^{-1}$

$\Delta_f H^\circ(CO_2(g)) = -394 \text{ kJ mol}^{-1}$

$\Delta_f H^\circ(H_2O(g)) = -242 \text{ kJ mol}^{-1}$

(ii) Explain what would happen to the $\Delta_r H^\circ$ provided in part (i) if the water was produced as a liquid, $H_2O(\ell)$.

QUESTION THREE

(a) (i) Complete the following table.

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

(ii) Explain why the radii of the Ca atom and Ca^{2+} ion are different.

	Radius / pm
Ca atom	197
Ca^{2+} ion	100

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

Substance	Boiling point / °C	Attractive forces
Propan-1-amine, $CH_3CH_2CH_2NH_2(\ell)$	48.5	
Chloroethane, $CH_3CH_2Cl(\ell)$	12.3	
Decane $CH_3(CH_2)_8CH_3(\ell)$	174	

(ii) Explain why the boiling point of propan-1-amine is higher than that of chloroethane.

(iii) Explain why the boiling point of decane is higher than that of chloroethane.

Question Three continues on the next page.

(c) Glucose, $C_6H_{12}O_6(s)$, reacts with oxygen, $O_2(g)$, to produce carbon dioxide, $CO_2(g)$, and water vapour, $H_2O(g)$, as shown in the equation below:

$$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(g)$$

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

$$\Delta_f H°(C_6H_{12}O_6(s)) = -1270 \text{ kJ mol}^{-1}$$
$$\Delta_c H°(C(s)) = -394 \text{ kJ mol}^{-1}$$
$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(\ell) \qquad \Delta_c H°(H_2(g)) = -286 \text{ kJ mol}^{-1}$$
$$\Delta_{vap} H°(H_2O(\ell)) = +6.01 \text{ kJ mol}^{-1}$$

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