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90699

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Level 3 Chemistry, 2005

90699 Describe and use thermochemical principles

Credits: Three
9.30 am Wednesday 23 November 2005

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 answer ALL the questions in this booklet.

Show all working for all calculations.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

A periodic table is provided on the Resource Sheet in your Level 3 Chemistry package.

Check that this booklet has pages 2–7 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.

For Assessor's use only	**Achievement Criteria**		
Achievement	**Achievement with Merit**	**Achievement with Excellence**
Describe and use thermochemical principles. ☐	Apply thermochemical principles to selected systems. ☐	Interpret and explain information in terms of thermochemical principles. ☐
Overall Level of Performance ☐		

You are advised to spend 30 minutes answering the questions in this booklet.

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QUESTION ONE: EXTRACTION OF HYDROGEN

The following reactions are involved in the extraction of hydrogen from coal.

(a) Coal is converted to carbon monoxide according to the following equation.

$$C(s) + \tfrac{1}{2}O_2(g) \rightarrow CO(g)$$

Calculate the enthalpy change for the reaction above using the following information.

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta_r H = -394 \text{ kJ mol}^{-1}$$

$$CO(g) + \tfrac{1}{2}O_2(g) \rightarrow CO_2(g) \qquad \Delta_r H = -283 \text{ kJ mol}^{-1}$$

(b) The carbon monoxide produced above is reacted with steam to produce hydrogen gas.

$$CO(g) + H_2O(g) \rightarrow H_2(g) + CO_2(g) \qquad \Delta_r H = -41.2 \text{ kJ mol}^{-1}$$

Bond	Bond enthalpy (kJ mol^{-1})
O–H	463
H–H	436
C=O	743

(i) The bond enthalpies for the carbon to oxygen bonds in CO_2 and CO are different. Use the bond enthalpies in the table and the enthalpy of the reaction to calculate the bond enthalpy of the carbon to oxygen bond in carbon monoxide.

(ii) Why are bond enthalpy values always positive?

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(iii) Explain the difference between the following bond enthalpies.

Bond	Bond enthalpy (kJ mol^{-1})
C=O	743
C–O	351

QUESTION TWO: FIREWORKS

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(a) Barium nitrate is one of the components of 'sparklers'. The standard enthalpy of formation ($\Delta_f H°$) of solid barium nitrate, $Ba(NO_3)_2$, is –992 kJ mol^{-1}.

Write the balanced equation for the reaction that gives the enthalpy of formation of $Ba(NO_3)_2$. Include the state of each species in this reaction.

(b) The reaction that occurs when 'sparklers' burn is:

$$10Al(s) + 3Ba(NO_3)_2(s) \rightarrow 3BaO(s) + 3N_2(g) + 5Al_2O_3(s)$$

Calculate the enthalpy change for this reaction using the data given below.

Compound	**$\Delta_f H°$ (kJ mol^{-1})**
$Ba(NO_3)_2(s)$	–992
$BaO(s)$	–554
$Al_2O_3(s)$	–1676

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(c) The principle of a fireworks-type explosion can be demonstrated by igniting a sucrose jelly-baby with sodium chlorate, $NaClO_3$.

The equation for the explosion reaction is:

$$2NaClO_3(s) + C_{12}H_{22}O_{11}(s) \rightarrow 2NaCl(s) + 9C(s) + 3CO_2(g) + 11H_2O(g)$$
$$\Delta_r H^\circ = -2192 \text{ kJ mol}^{-1}$$

(i) Calculate the quantity of heat released when one jelly-baby containing 4.56 g of sucrose ($C_{12}H_{22}O_{11}$) is exploded.

$$M(C_{12}H_{22}O_{11}) = 342 \text{ g mol}^{-1}$$

(ii) The heat released by the explosion can be used to vaporise strontium chloride to give the fireworks colour.

The heat required to convert $SrCl_2$ from the solid to the gas state is 343 kJ mol^{-1}.

Use your answer to (i) above to calculate the mass of solid $SrCl_2$ that can be vaporised by exploding one jelly baby containing 4.5 g of sucrose.

$$M(SrCl_2) = 159 \text{ g mol}^{-1}$$

QUESTION THREE: BONDING

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(a) Describe what is meant by the term '**hydrogen bonding**'.

(b) Discuss the nature of the forces between molecules in each of the **three** substances given in the table below, **and** account for the variation in the melting points.

Substance	Formula	Molar mass (g mol^{-1})	Melting point (^oC)
Propanoic acid	CH_3CH_2COOH	74	–20.8
Butanoic acid	$CH_3CH_2CH_2COOH$	88	–4.3
Ethyl ethanoate	$CH_3COOCH_2CH_3$	88	–83.6

Extra paper for continuation of answers if required.
Clearly number the question.

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Question number	