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VCE Chemistry $\frac{3}{4}$
Thermochemistry [1.1]
Homework

Homework Outline:

Compulsory Questions	Pg 02 – Pg 12
Supplementary Questions	Pg 12 – Pg 23
Solutions	Pg 02 – Pg 23



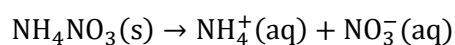
Section A: Compulsory Questions (37 Marks)

Sub-Section: [1.1.1] Identify ΔH and E_a in endothermic/exothermic energy profile diagrams

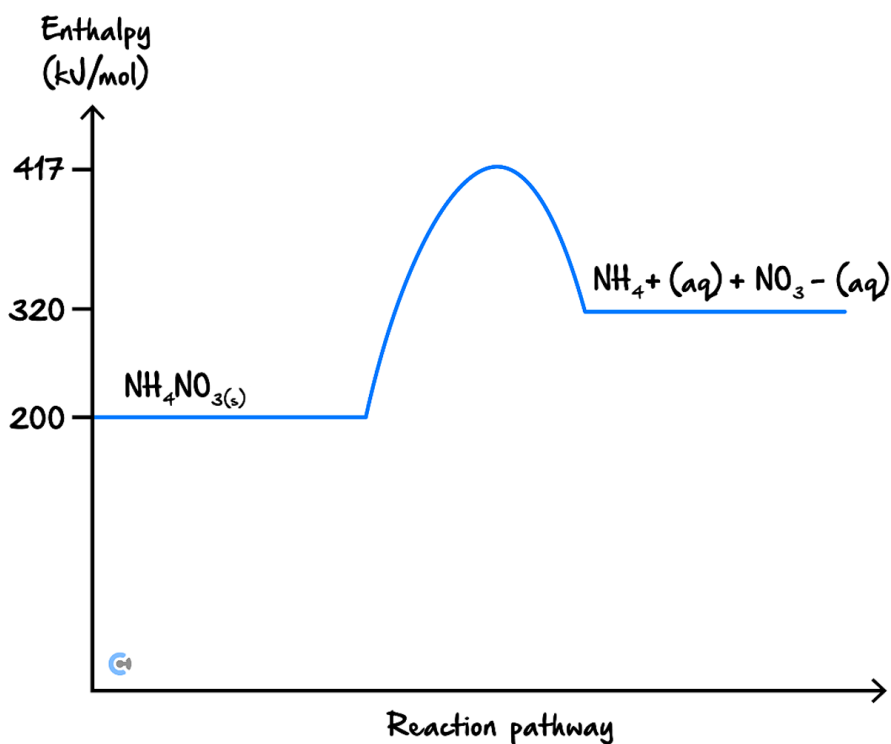
Question 1 (2 marks)

Consider the following energy profile diagrams.

Ammonium nitrate ($\text{NH}_4\text{NO}_3(\text{s})$) can undergo dissociation in the following reaction:



The energy profile diagram for the reaction is shown below:



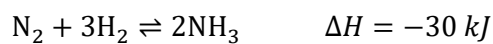
- a. Determine the ΔH value of the dissociation of $\text{NH}_4\text{NO}_3(\text{s})$. (1 mark)

- b. Find the activation energy of this reaction. (1 mark)



Question 2 (2 marks)

The chemical equation for a variation of the Haber process has been shown below:



The following energy profile is created based on experimental observations.



- a. State whether the reaction is exothermic or endothermic. (1 mark)

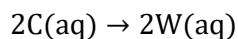
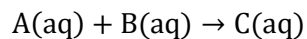
- b. Hence, determine whether the energy profile represents the forward or backward reaction. (1 mark)

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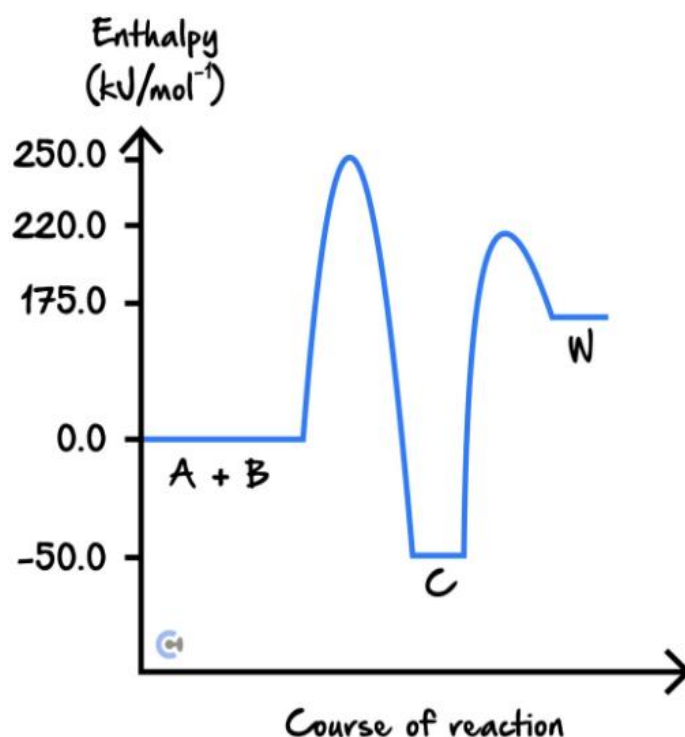


Question 3 (6 marks)

Compound W is produced in industry via a two-step process. The two reactions involved in the production of W are shown below.



The energy profile diagram of the entire process is shown below.



- a. State the activation energy required for the second reaction to occur. (1 mark)

- b. Determine the overall enthalpy of the reaction. (1 mark)

- c. Hence, state and justify whether the overall reaction is exothermic or endothermic. (2 marks)

d. Explain whether the production of $W(aq)$ will happen in nature by itself. Justify your response. (2 marks)

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Sub-Section: [1.1.2] Identify differences between complete and incomplete combustion & write their thermochemical combustion equations

Question 4 (2 marks)



Consider the following substances which have been combusted.

Write balanced thermochemical chemical equations for the following reaction:

- a. The complete combustion of butane gas (C_4H_{10}). (1 mark)

- b. The incomplete combustion of propane gas (C_3H_8), forming carbon monoxide by-product, where 1500 kJ mol^{-1} of energy is released. (1 mark)

Question 5 (3 marks)



Liquid hexane is combusted under an open Bunsen burner flame in a fume hood. Emma accidentally leaves the Bunsen burner airhole closed.

- a. Emma notices black soot accumulating along the circumference of the beaker containing hexane liquid. Explain the cause for this observation. (2 marks)

- b. **Hence**, write a balanced equation for the incomplete combustion of liquid hexane occurring in Emma's bunsen burner. (1 mark)

Question 6 (3 marks)


Noah combusts $C_{19}H_{38}O_2(l)$ under a Bunsen burner flame.

- a. Write a balanced chemical equation for the incomplete combustion of $C_{19}H_{38}O_2(l)$, whereby the only carbon-containing products are carbon (C). (1 mark)

- b. Hence or otherwise, explain whether the complete or incomplete combustion reaction will have a greater change in enthalpy. (2 marks)

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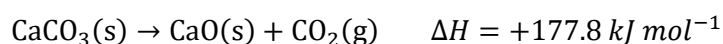
Sub-Section: [1.1.3] Apply changing equations to thermochemical equations energy profile diagrams

Question 7 (3 marks)

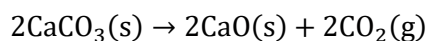


Consider the following thermochemical equations.

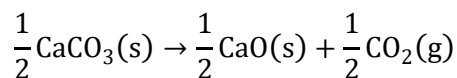
Calcium carbonate can undergo decomposition under the following reaction:



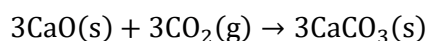
- a. Calculate the ΔH for the reaction represented by the equation: (1 mark)



- b. Calculate the ΔH for the reaction represented by the equation: (1 mark)



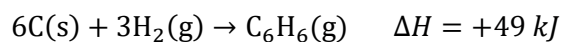
- c. Calculate the ΔH for the reaction represented by the equation: (1 mark)



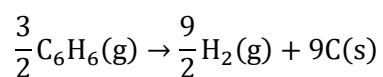
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Question 8 (3 marks)

The following reaction occurs in a beaker.



During experimentation, the following reaction is obtained:



- a. State whether the new reaction is exothermic or endothermic. (1 mark)

- b. Calculate the ΔH for the reaction represented by the equation. (1 mark)

- c. State **two** experimental observations that will be observed in the beaker during the reaction. (1 mark)

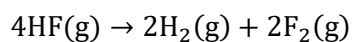
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Question 9 (3 marks)

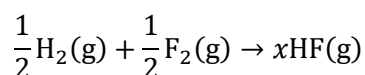
Hydrofluoric acid has applications in the pharmaceutical industry. It can be produced through the reaction shown below:



- a. Calculate the ΔH for the reaction represented by the equation: (1 mark)



- b. Calculate the ΔH for the reaction represented by the equation, and find the value of the coefficient ' x '. (2 marks)



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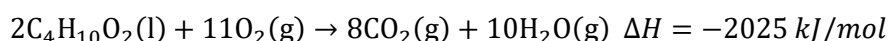
Sub-Section: The Final Boss

Question 10 (10 marks)

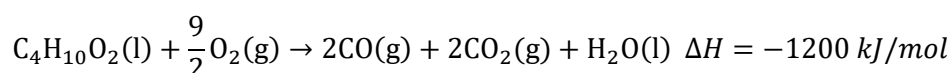


The following reactions represent butane-1,2-diol ($C_4H_{10}O_2$) and are associated with energy profile diagrams.

Reaction 1:

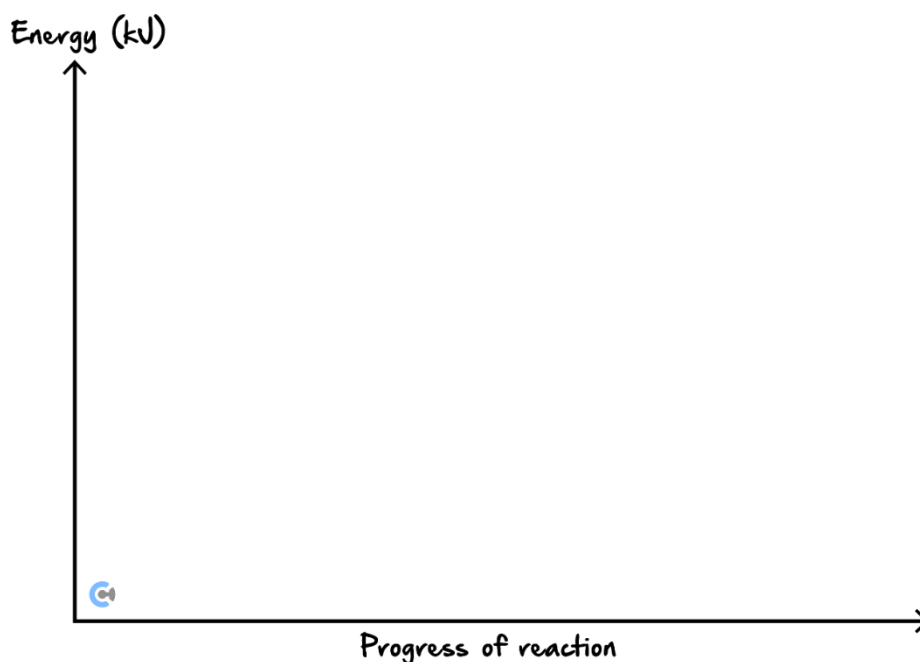


Reaction 2:



- a. Explain which reaction, complete or incomplete, releases more energy and why this is the case based on the provided ΔH values. (2 marks)

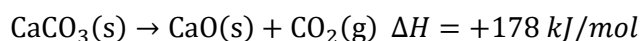
- b. Draw and label an energy profile diagram for Reaction 1. Include labels for the activation energy (kJ), enthalpy change (ΔH), reactants, and products. (2 marks)



- c. With reference to activation energy, explain why incomplete combustion might occur more easily than complete combustion under certain conditions. (2 marks)

- d. Describe the effect of changing the ratio of oxygen in the combustion of butane-1,2-diol, and how this relates to whether complete or incomplete combustion occurs. (2 marks)

- e. Consider the thermochemical equation for the decomposition of calcium carbonate:



If the equation is doubled, what happens to the value of ΔH , and how would this be reflected in an energy profile diagram? (2 marks)

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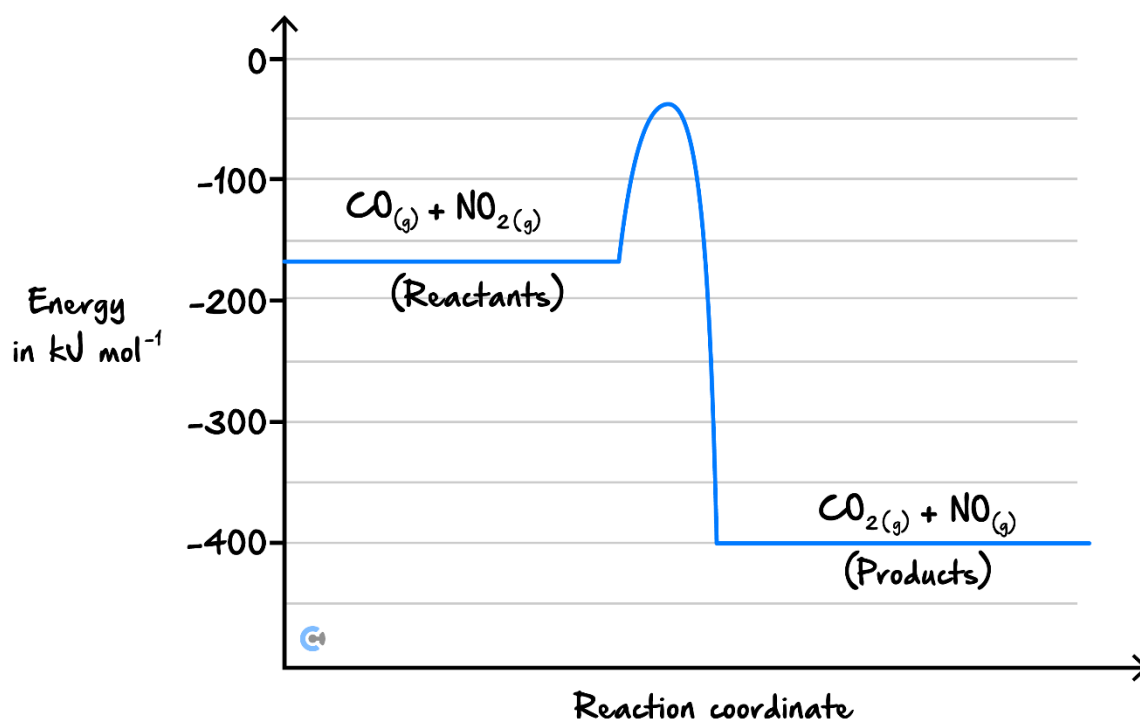
Section B: Supplementary Questions (44 Marks)

Sub-Section: [1.1.1] Identify ΔH and E_a in endothermic/exothermic energy profile diagrams

Question 11 (3 marks)

Consider the following energy profile diagrams.

A student observes the following energy profile diagram below.



- a. State whether the reaction is endothermic or exothermic. (1 mark)

- b. State the activation energy (kJ) required for the reaction to occur. (1 mark)

- c. Calculate the ΔH value for this reaction. (1 mark)



Question 12 (6 marks)

An upcoming scientist is exploring a new reaction. She notices that the energy required to break the bonds in the reactants and form the product is equal to 770 kJ mol^{-1} . Secondly, she finds that the amount of energy absorbed, has a magnitude of 500 kJ mol^{-1} . Additionally, she notices the temperature of the test tube drops when this reaction occurs.

- a. Draw an energy diagram showing the enthalpy of reactants and products. (2 marks)



- b. Label the activation energy and change in enthalpy on the energy diagram drawn in **part b.i.** (1 mark)
- c. State whether the reaction is exothermic or endothermic. (1 mark)

- d. Alex claims that an exothermic reaction will always have an activation energy that is always bigger in magnitude than the ΔH value, whereas James says this is only true for endothermic reactions. Determine who is correct. (**Hint:** Draw both out.) (2 marks)

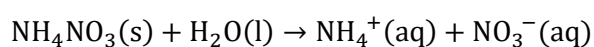
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Question 13 (4 marks)

Kevin bruises his leg playing soccer and uses an instant ice pack to help with the inflammation. He is told that when you activate the ice pack (by snapping it), it activates a chemical reaction. The ice pack is ready to use within 30-60 seconds.

- a. State the type of chemical reaction (endothermic or exothermic) occurring when the ice pack is snapped. (1 mark)

- b. Kevin is told that the following chemical reaction is occurring in the icepack:



He is told that the ΔH value is 25.7 kJ/mol , but cannot remember if the value should be positive or negative.

State whether the value should be positive or negative. (1 mark)

- c. Explain the purpose of snapping the ice pack. (2 marks)

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Sub-Section: [1.1.2] Identify differences between complete and incomplete combustion & write their thermochemical combustion equations

Question 14 (2 marks)



Consider the following substances which have been combusted.

Write balanced thermochemical chemical equations for the following reactions:

- a. The complete combustion of methane gas (CH_4). (1 mark)

- b. The incomplete combustion of hexane liquid (C_6H_{14}), forming carbon byproduct, where 2220 kJ mol^{-1} of energy is released. (1 mark)

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Question 15 (4 marks)

An experiment is conducted where methanol is combusted in a low-oxygen environment.

- a. State the type of reaction that will occur.

- b. Write a balanced chemical equation for the reaction occurring, given that no carbon monoxide is detected in the experiment. (1 mark)

- c. James explains that incomplete combustion is more efficient than complete combustion, as less energy is required to obtain products. Evaluate this statement. (3 marks)

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Question 16 (3 marks)

An experiment was conducted where $C_{20}H_{40}O_2$ was combusted, where the fuel was the excess reagent.

Following the combustion, the experimenter noticed a thick black coating along the beaker which contained the fuel. No other carbon by-products were produced.

- a. Write a balanced chemical equation for the reaction. (1 mark)

- b. State what likely caused the black residue on the beaker. (1 mark)

- c. Predict whether the reaction was exothermic or endothermic. (1 mark)


Question 17 (7 marks)

A complete combustion reaction occurs with ethanol, over an open Bunsen burner flame.

- a. Write a thermochemical equation for the reaction occurring. (1 mark)

b. In another experiment, the Bunsen burner hole is closed partially, causing the flame to change from blue to orange. The ethanol sample is then combusted under the open flame.

i. Explain why the colour change of the flame occurred. (2 marks)

ii. Write a balanced chemical equation for the reaction occurring, given that carbon monoxide and carbon soot are produced. (1 mark)

iii. State which reactant is reacting in excess. (1 mark)

c. Predict and justify whether the ΔH value for this reaction will be greater or less than that of **part a.** (2 marks)

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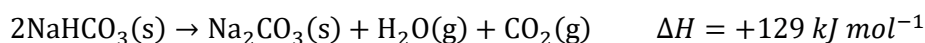
Sub-Section: [1.1.3] Apply changing equations to thermochemical equations energy profile diagrams

Question 18 (3 marks)

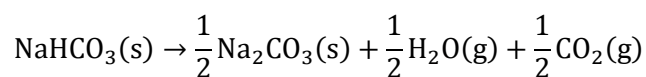


Consider the following thermochemical equations.

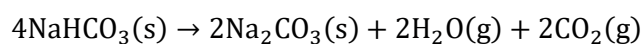
A reaction occurs, as shown in the following chemical equation:



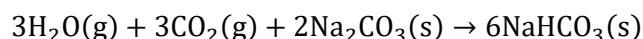
- a. Calculate the ΔH for the reaction represented by the equation: (1 mark)



- b. Calculate the ΔH for the reaction represented by the equation: (1 mark)



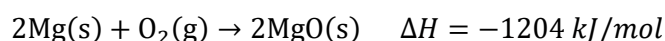
- c. Calculate the ΔH for the reaction represented by the equation: (1 mark)



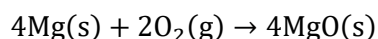
Question 19 (2 marks)



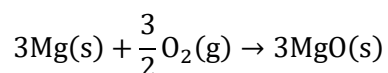
A reaction occurs, as shown in the following chemical equation:



- a. Calculate the ΔH for the reaction represented by the equation: (1 mark)



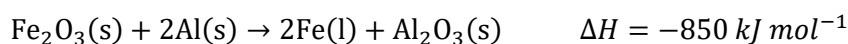
- b. Calculate the ΔH for the reaction represented by the equation: (1 mark)



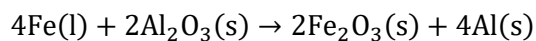
Question 20 (3 marks)



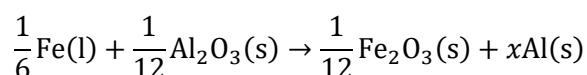
Iron (III) oxide has applications in the pharmaceutical industry. It can be produced through the reaction shown below:



- a. Calculate the ΔH for the reaction represented by the equation: (1 mark)



- b. Calculate the ΔH for the reaction represented by the equation, and find the value of the coefficient 'x'. (2 marks)



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Question 21 (7 marks)

Anna is combusting a sample of $\text{C}_5\text{H}_{11}\text{OH}(\text{l})$ over a Bunsen burner flame. If combusted completely, for every mole of pentanol, 3256 kJ of energy is released.

- a. Given that a complete combustion reaction occurs, write a balanced chemical equation for the reaction. (1 mark)

- b. State whether the reaction is exothermic or endothermic. Justify your response. (2 marks)

- c. Anna is trying to determine the chemical equation from the following ΔH values.

- i. $\Delta H = +3256 \text{ kJ/mol}$. (1 mark)

- ii. $\Delta H = -6512 \text{ kJ/mol}$. (1 mark)

- iii. $\Delta H = -2170.67 \text{ kJ/mol}$. (2 marks)

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