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NZQA
NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

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# Level 2 Chemistry, 2007

## 90310 Describe thermochemical and equilibrium principles

Credits: Five
2.00 pm Monday 19 November 2007

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

A Periodic Table is provided on the RESOURCE SHEET in your Level 2 Chemistry package.

You should answer ALL the questions in this booklet.

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

Check that this booklet has pages 2–9 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 thermochemical and equilibrium principles. ☐ | Interpret information about thermochemical and equilibrium systems. ☐ | Discuss information about thermochemical and equilibrium systems. ☐ |
| **Overall Level of Performance** ☐ | | |

You are advised to spend 55 minutes answering the questions in this booklet.

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## QUESTION ONE

(a) The bicarbonate ion, $HCO_3^-$, can both accept and donate hydrogen ions (protons). Complete the equations below.

$HCO_3^- + H_2O \rightleftharpoons H_3O^+ +$ _____ **Reaction A**

$HCO_3^- + H_2O \rightleftharpoons OH^- +$ _____ **Reaction B**

(b) When sodium bicarbonate, $NaHCO_3$, dissolves in water the solution is basic.

Circle **Reaction A** or **Reaction B** to show which reaction predominates.

Justify your answer.

_____

_____

## QUESTION TWO

(a) Give the pH of 0.125 mol $L^{-1}$ HCl.

_____

(b) Calculate the hydroxide ion concentration of NaOH solution at pH 10.2.

_____

_____

_____

(c) Calculate the pH of 0.124 mol $L^{-1}$ NaOH.

_____

_____

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## QUESTION THREE

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An experiment was carried out by reacting zinc metal with excess dilute sulfuric acid. All the zinc was used up in the reaction. The equation for this reaction is shown below.

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)$$

(a) The experiment was repeated, but this time 2 mL water was also added to the beaker. Again the zinc was all used up.

Explain why:

when water is added, the rate of reaction will decrease.

(b) Small pieces of copper can act as a **catalyst** for the **reaction** between zinc and dilute sulfuric acid.

Discuss how this claim could be tested by experiment.

## QUESTION FOUR

Assessor's use only

(a) Classify the following reactions as exothermic or endothermic by writing in the box the word that best represents each equation.

| | | **Exothermic** or **Endothermic** |
|---|---|---|
| (i) | $NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O$<br>A temperature increase occurs. | |
| (ii) | $N_2(g) \longrightarrow 2N(g)$<br>$\Delta_r H = +934$ kJ mol$^{-1}$ | |
| (iii) | $H_2(g) + I_2(g) \longrightarrow 2HI(g)$<br>A temperature decrease occurs. | |
| (iv) | $2H_2(g) + CO(g) \longrightarrow CH_3OH(g)$<br>$\Delta_r H = -128$ kJ mol$^{-1}$ | |

(b) Dissolving of ammonium nitrate in water is an endothermic process.

$$NH_4NO_3(s) \longrightarrow NH_4^+(aq) + NO_3^-(aq)$$

(i) When 1.80 g of ammonium nitrate was dissolved in 50.0 g of water, the temperature decreased by 2.70°C. The heat capacity of water is 4.18 J g$^{-1}$ °C$^{-1}$.
$M(NH_4NO_3) = 80.0$ g mol$^{-1}$

Calculate the enthalpy change when one mole of ammonium nitrate dissolves completely in water.

(ii) Calculate the mass of ammonium nitrate that would be required to absorb 1.25 kJ of energy.

## QUESTION FIVE

Assessor's use only

The following equilibrium system is formed when potassium thiocyanate solution is added to a solution of iron(III) nitrate.

$$\underset{\text{orange}}{Fe^{3+}(aq)} + \underset{\text{colourless}}{SCN^{-}(aq)} \rightleftharpoons \underset{\text{dark red}}{FeSCN^{2+}(aq)}$$

The reaction has a positive value for $\Delta_r H$.

For each of the following changes applied to this system:

(i) describe the expected observation
(ii) use equilibrium principles to discuss the reason for this observation.

(a) The reaction mixture is cooled.

(i) _____

(ii) _____

_____

_____

_____

(b) Solid sodium fluoride is added to the reaction mixture. The fluoride ions react with $Fe^{3+}$ ions.

(i) _____

(ii) _____

_____

_____

_____

(c) Solid iron(III) chloride is added to the reaction mixture.

(i) _____

(ii) _____

_____

_____

_____

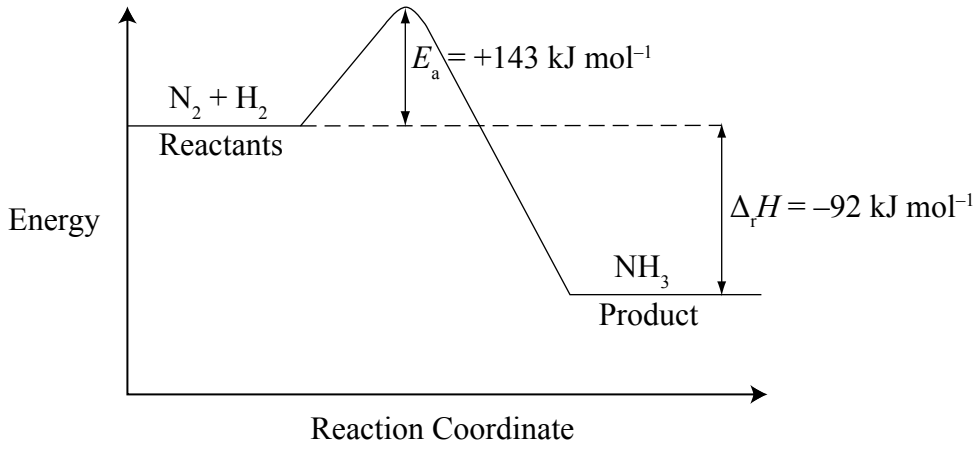
## QUESTION SIX

Assessor's use only

For the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$,

the enthalpy of reaction $\Delta_r H = -92$ kJ mol$^{-1}$, and the activation energy $E_a = +143$ kJ mol$^{-1}$.

An energy diagram for this chemical reaction is shown below.




The reverse reaction is $2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$

(a) Complete the equilibrium constant expression for this reverse reaction.

$K_c =$

(b) State the values for $\Delta_r H$ and $E_a$ for this reverse reaction.

$\Delta_r H =$ _____ kJ mol$^{-1}$ $E_a =$ _____ kJ mol$^{-1}$

(c) Draw the energy diagram below for this reverse reaction.
Label the diagram with the four labels from the key list.

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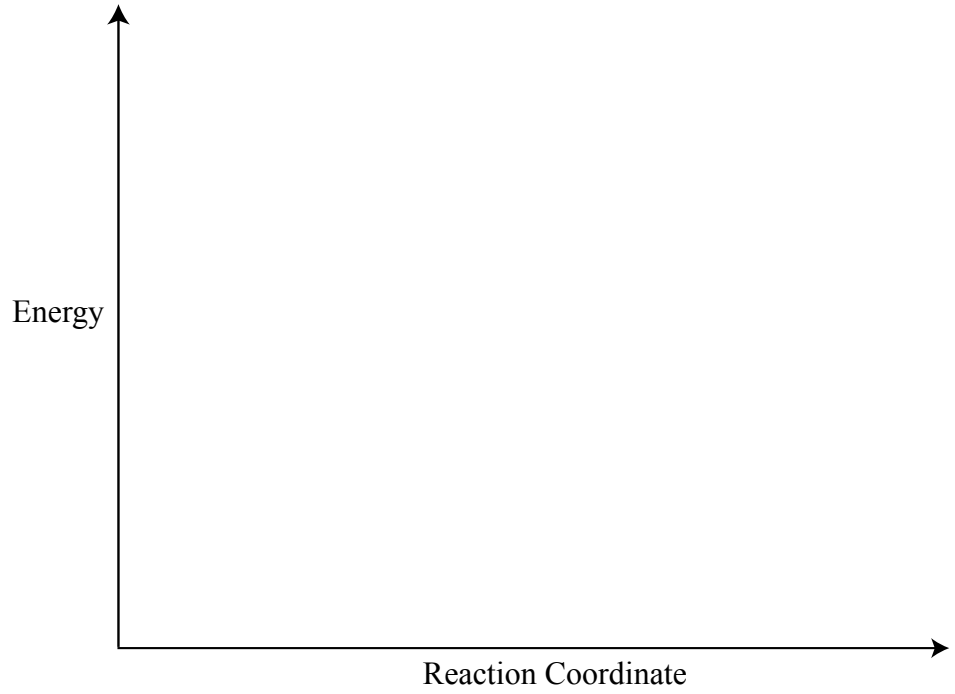
KEY LIST: $N_2 + H_2$ $NH_3$ $\Delta_r H$ $E_a$




**PLEASE TURN OVER TO PAGE 8 FOR QUESTION SEVEN**

## QUESTION SEVEN

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Methyl orange can be used as an acid-base indicator. It is pink in solutions with a pH less than 3 and yellow in solutions with a pH greater than 4.

Four beakers are known to contain one each of:

- 0.1 mol $L^{-1}$ HCl
- 0.01 mol $L^{-1}$ HCl
- distilled water
- 0.1 mol $L^{-1}$ NaOH

(a) Complete the following table.

| | pH | Colour of methyl orange |
|---|---|---|
| 0.1 mol $L^{-1}$ HCl | | |
| 0.01 mol $L^{-1}$ HCl | | |
| distilled water | | |
| 0.1 mol $L^{-1}$ NaOH | | |

(b) Using **only** the methyl orange indicator, **additional** water, test tubes and a **measuring cylinder**, discuss how a student could identify each of the four solutions.

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

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| Question number | |
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