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90310

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NZQA
NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

For Supervisor's use only

Level 2 Chemistry, 2009

90310 Describe thermochemical and equilibrium principles

Credits: Five
2.00 pm Monday 23 November 2009

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.

A periodic table is provided on the Resource Sheet L2–CHEMR.

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 2–12 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.

Assessor's use only

QUESTION ONE

(a) Complete the equations below to show how each species will react with water to form an acidic solution.

(i) $HCl + H_2O \rightarrow$ _____

(ii) $CH_3COOH + H_2O \rightleftharpoons$ _____

(b) (i) Determine the $[H_3O^+]$, $[OH^-]$, and pH in each of the following two solutions. The $[H_3O^+]$ for HCl has been listed.

0.0376 mol L^{-1} HCl solution.

$[H_3O^+]$ / mol L^{-1}	$[OH^-]$ / mol L^{-1}	pH
0.0376		

2.48×10^{-4} mol L^{-1} NaOH solution.

$[H_3O^+]$ / mol L^{-1}	$[OH^-]$ / mol L^{-1}	pH

(ii) Explain why the concentration of the acid, HCl, is equal to the concentration of the hydronium ion, H_3O^+.

_____

_____

_____

_____

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(iii) The concentration of the hydronium ion, H_3O^+, in a 0.0376 mol L^{-1} solution of CH_3COOH is less than 0.0376 mol L^{-1}.

Explain why the concentration of the hydronium ion is less than 0.0376 mol L^{-1}.

(c) Conductivity of solutions can be described as being **high**, **low**, or having **no conductivity**.

Compare and contrast the conductivity of the three solutions shown below.

0.100 mol L^{-1} HCl
0.100 mol L^{-1} CH_3COOH
0.100 mol L^{-1} NaOH

QUESTION TWO

Assessor's use only

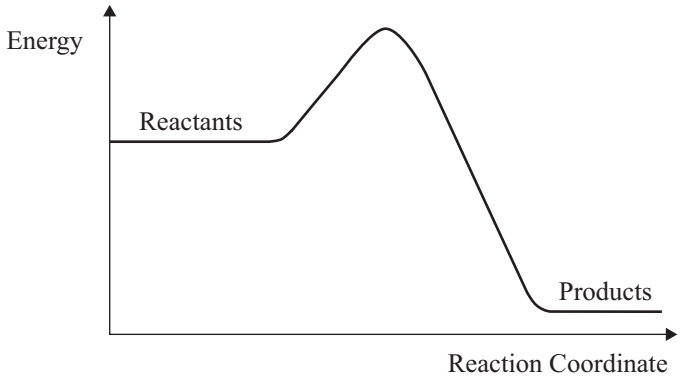
(a) For the reaction $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$,

the enthalpy of reaction is $\Delta_r H = -950$ kJ mol^{-1}.

The reverse reaction is $4NO(g) + 6H_2O(g) \rightleftharpoons 4NH_3(g) + 5O_2(g)$

Two energy diagrams are shown below. One is for the forward reaction and one is for the same reaction in the reverse direction.

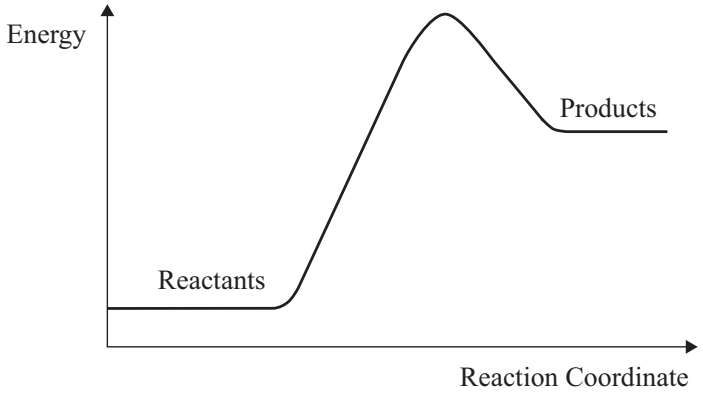
Diagram One



Exothermic or **Endothermic**
(*circle one*)

Forward or **Reverse**
(*circle one*)

Diagram Two



Exothermic or **Endothermic**
(*circle one*)

Forward or **Reverse**
(*circle one*)

(i) For each diagram, **circle** the correct answer to indicate whether the diagram is for an **exothermic** reaction or an **endothermic** reaction.

(ii) For each diagram, **circle** the correct answer to indicate whether the diagram is for the **forward** reaction or for the **reverse** reaction.

(iii) On the diagrams for **both** reactions, also label the following:

- enthalpy of reaction, $\Delta_r H$
- Activation Energy, E_a.

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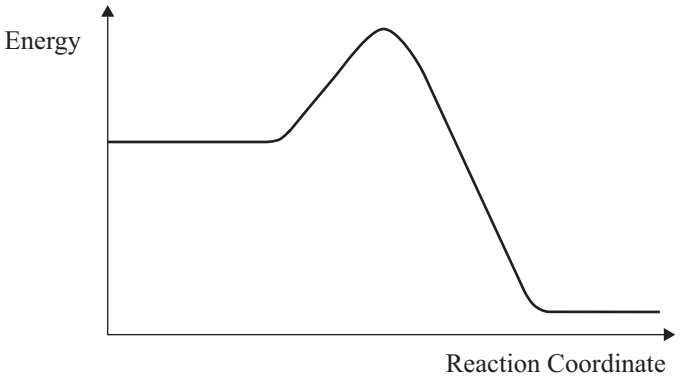
(iv) Determine the value for the enthalpy of reaction ($\Delta_r H$) for the reaction shown in **Diagram Two**.

Explain how you determined this value.

(b) The energy diagram below represents a reaction carried out at 20°C.



(i) On the same axes, redraw the energy diagram to show the same reaction carried out at a higher temperature.

(ii) Explain any changes to

- enthalpy of reaction, $\Delta_r H$
- Activation Energy, E_a
- energy of the reactants
- energy of the products.

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(c) The equation for the reaction between calcium oxide, CaO, and water can be represented as

$$CaO(s) + H_2O(\ell) \rightarrow Ca(OH)_2(aq) \qquad \Delta H = -82.0 \text{ kJ mol}^{-1}$$

$$M(CaO) = 56.0 \text{ g mol}^{-1}$$

Calculate the mass of calcium oxide required to release 287 kJ of energy.

QUESTION THREE

(a) Nitrogen monoxide gas reacts with oxygen gas to form nitrogen dioxide gas. The equilibrium reaction can be represented by:

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

colourless colourless brown

At 230°C the equilibrium constant for this reaction has a value of 6.44×10^5.

(i) Complete the equilibrium constant expression for this reaction.

$K_c =$

(ii) State which gas will be in the highest concentration at 230°C.

Explain your answer in terms of K_c and the colour seen.

Assessor's use only

(b) The following equilibrium system is formed when hydrogen gas is mixed with iodine gas.

$$\underset{\text{colourless}}{H_2(g)} + \underset{\text{purple}}{I_2(g)} \rightleftharpoons \underset{\text{colourless}}{2HI(g)}$$

The reaction has a negative 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.

HI(*g*) is added.

Expected observation: _____

Reason: _____

_____

_____

_____

The reaction mixture is cooled.

Expected observation: _____

Reason: _____

_____

_____

_____

The pressure is increased.

Expected observation: _____

Reason: _____

_____

_____

_____

QUESTION FOUR

Assessor's use only

(a) An experiment was carried out by reacting calcium carbonate with dilute hydrochloric acid.

The equation for this reaction can be represented by:

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(\ell)$$

State THREE ways to increase the rate of this reaction.

(1) _____

(2) _____

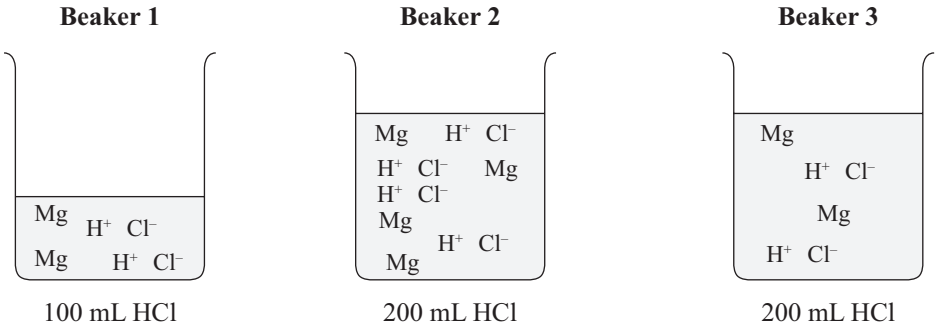
(3) _____

(b) Three experiments were carried out by reacting magnesium metal with hydrochloric acid.

The equation for this reaction can be represented by:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

The beakers drawn below show particle representations of magnesium metal and hydrochloric acid just before the reaction is about to begin.



Mg = particles of magnesium metal

H^+ Cl^- = particles of hydrochloric acid

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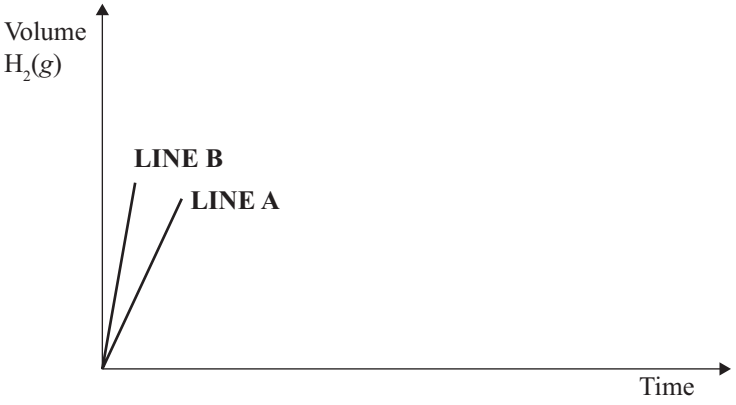
The rate of reaction can be followed by recording the volume of hydrogen, H_2, produced. The graph below shows the volume of hydrogen produced during the **initial** part of the reaction.



Which beaker(s) corresponds to:

LINE A of the graph _____ **LINE B** of the graph _____

Explain your answers in terms of

- particle collision
- concentration of the particles present.

Question Four (c) is on the following page.

Assessor's use only

(c) An experiment was carried out by reacting bromine, Br_2, and methanoic acid, HCOOH, in a beaker. The equation for this reaction can be represented by:

$$\underset{\text{brown}}{Br_2(aq)} + \underset{\text{colourless}}{HCOOH(aq)} \rightarrow 2Br^-(aq) + 2H^+(aq) + \underset{\text{all colourless}}{CO_2(g)}$$

The rate of reaction can be followed by measuring the time taken for the solution to **go colourless**.

A series of reactions were carried out and the time taken for the solution to go colourless was recorded. The results are shown below.

Temperature of solution / °C	10	20	30	40	50
Time taken to go colourless / s	34	28	21	15	7

(i) Describe the trend shown by these results.

(ii) Discuss the reasons for this trend.

Your answer must include reference to

- particle collision
- reaction rate
- Activation Energy.

Assessor's use only

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

Assessor's use only

Question number