AQA

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme January 2004

GCE

Chemistry

Unit CHM2

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SECTION A

Answer **all** questions in the spaces provided.

1 Hydrogen is produced on an industrial scale from methane as shown by the equation below.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \quad \Delta H^{\ominus} = +205\,kJ\,mol^{-1}$$

(a) State Le Chatelier's principle.

An equilibrium opposes change (1)

(1 mark)

(b) The following changes are made to this reaction at equilibrium. In each case, predict what would happen to the yield of hydrogen from a given amount of methane. Use Le Chatelier's principle to explain your answer.

(i) The overall pressure is increased.

note C.E if not decrease but mark on if no answer

Effect on yield of hydrogen decrease (1)

Explanation pressure lowered (or increase opposed) (1)

by favouring fewer moles (of gas) (1)

(ii) The concentration of steam in the reaction mixture is increased.

C.E if wrong as above

Effect on yield of hydrogen increase (1)

Explanation {pressure / concentration} {reactants: steam reduced (1) or steam removed} by shifting to right (1) or forward reaction favoured

(6 marks)

(c) At equilibrium, a high yield of hydrogen is favoured by high temperature. In a typical industrial process, the operating temperature is usually less than 1200 K. Suggest two reasons why temperatures higher than this are not used.

Reason 1 cost of {high temperature / energy} (1)

Reason 2 cost of plant (to resist high T) too high (1)

OR plant could not contain high T

(2 marks)

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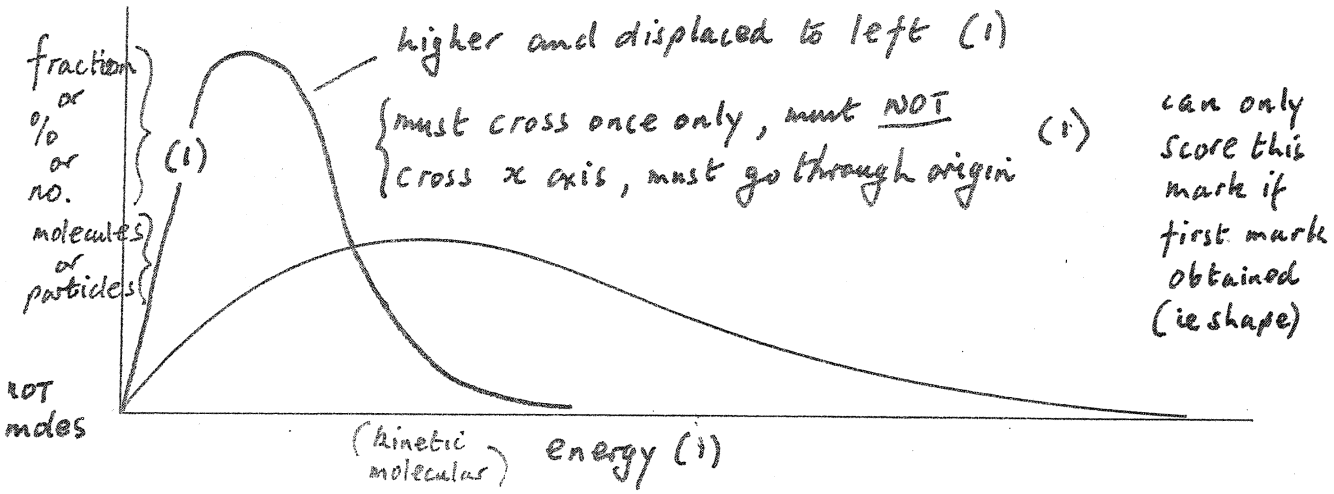
2 The diagram below represents a Maxwell–Boltzmann distribution curve for the particles in a sample of a gas at a given temperature. The questions below refer to this sample of particles.



(a) Label the axes on the diagram. *(2 marks)*

(b) On the diagram draw a curve to show the distribution for this sample at a **lower** temperature. *(2 marks)*

(c) In order for two particles to react they must collide. Explain why most collisions do not result in a reaction.

energy < Ea (1) or must have enough energy (to react)

(1 mark)

(d) State one way in which the collision frequency between particles in a gas can be increased without changing the temperature.

increase concentration (or pressure) (1)

(1 mark)

(e) Suggest why a small increase in temperature can lead to a large increase in the reaction rate between colliding particles.

many (1) more molecules have { E > Ea (1) / enough energy

(NOT KE increases with T)

(2 marks)

(f) Explain in general terms how a catalyst works.

lowers Ea (1)

alternative route (1)

(2 marks)

3 (a) Identify the halogen that is the strongest oxidising agent.

fluorine or F_2 or F (1) NOT Fl.

(1 mark)

(b) Give the formula of the halide ion that is the strongest reducing agent.

I^- (or At^-) (1) allow $+e^-$ but not equation

(1 mark)

(c) Describe what you would observe in each case when aqueous silver nitrate is added separately to dilute aqueous sodium fluoride and to dilute aqueous sodium iodide. Write an equation, including state symbols, for the reaction between aqueous sodium iodide and aqueous silver nitrate.

Observation with NaF(aq) no change (1) OR colourless solution OR remains colourless

Observation with NaI(aq) yellow {solid precipitate (1)

Equation $I^-(aq) + Ag^+(aq) \rightarrow AgI(s)$ (1) no ss no marks

or $NaI(aq) + AgNO_3(aq) \rightarrow NaNO_3(aq) + AgI(s)$

(3 marks)

(d) Describe what you would observe when concentrated sulphuric acid is added to solid sodium chloride. Write an equation for the reaction that occurs.

Observation {steamy white misty fumes (1) NOT smoke gas

Equation $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$ ignore ss

(2 marks)

(e) Describe two observations that you would make when concentrated sulphuric acid is added to solid sodium iodide. Write an equation for a reaction that occurs in which iodide ions are oxidised by the sulphuric acid.

Observation 1 {black grey solid / {lilac purple gas / {pungent steamy choking fumes / steam } any two marks first one on each line

Observation 2 yellow solid / smell {bad eggs stink bombs (2)

Equation

$2NaI + 2H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + I_2 + SO_2$

two reduction products from Na_2SO_4 eg {H_2S or S or SO_2 + $I_2(s)$ (1)

balanced equation (1)

(4 marks)

(f) Describe the colour change that you would observe when an aqueous solution of iodine, to which starch solution has been added, reacts with an excess of $Na_2S_2O_3$. Write an equation for the reaction that occurs between iodine and $Na_2S_2O_3$.

Observation (starch) blue or black (1) → colourless (1)

Equation $I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$ (1)

(3 marks)

(or $I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$)

4 The extraction of metals involves redox reactions.

(a) In terms of electrons, state what happens in a redox reaction.

electrons transfered (1)

OR some lose e⁻, some gain e⁻s ... OR oxidation is loss of e OR reduction is gain in e

(1 mark)

(b) Titanium is extracted from titanium(IV) oxide in a two-step batch process.

(i) Write an equation for the first step in this process in which titanium(IV) oxide is converted into titanium(IV) chloride. Identify the oxidising and reducing agents in this step. or $TiO_2 + C + 2Cl_2 \rightarrow TiCl_4 + CO_2$ $C + Cl_2$ (1)

Equation $TiO_2 + 2C + 2Cl_2 \rightarrow TiCl_4 + 2CO$ balance (1)

Oxidising agent Cl_2 (1) (con = 0 marks if more than 1 species)

Reducing agent C (1) (allow coke, not coal)

(ii) Write an equation for the second step in this process in which titanium(IV) chloride is converted into titanium metal. State two important conditions for this step and in each case explain why the conditions are necessary.

Equation $TiCl_4 + \begin{matrix}4Na\\2Mg\end{matrix} \rightarrow Ti + \begin{matrix}4NaCl\\2MgCl_2\end{matrix}$ {Na (1) Mg balance (1)

Condition 1 high Temp (1) (500 -1000)

Explanation to speed up reaction (1)

OR otherwise too slow OR makes more reactants with $E > E_a$

Condition 2 Argon (1) (NOT inert atmosphere but mark on)

Explanation prevents oxidation of Mg/Na/Ti (1)

OR prevents contamination of Ti with O/N

OR prevents H_2O reacting with $TiCl_4$/Na/Mg *(10 marks)*

(c) Give the major reason why recycling aluminium is economically viable.

{electrolysis is expensive (1)
{electricity

(1 mark)

OR large energy cost to reduce Al_2O_3

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Q5 Marking Scheme

(a) (i) enthalpy (or heat or heat energy) change when 1 mol of a substance (1) (QL mark)
is formed from its elements (1)
all substances in their standard states (1) (or normal states at 298K, 100 kPa or std condits)
(**not** STP, NTP)

3 marks

(b) enthalpy change (or enthalpy of reaction) is independent of route (1)

$\Delta H = \Sigma\Delta H_f^{\ominus}$ prods - $\Sigma\Delta H_f^{\ominus}$ reactants (or cycle) (1)
minimum correct cycle is:

$$MgO + 2HCl \longrightarrow MgCl_2 + H_2O$$

$$Mg + Cl_2 + H_2 + \tfrac{1}{2}O_2$$

$\Delta H = -642 - 286 - (-602 + 2 \times -92)$ (1)
$= -142$ (kJ mol^{-1}) (1) penalise this mark for wrong units

(+142 scores 1 mark out of the last three)

4 marks

(c) $\Delta H = mcT$ (1) (or $mc\Delta T$)
$= 50 \times 4.2 \times 32 = 6720$ J $= 6.72$ kJ (1) (mark is for 6720 J or 6.72 kJ)

moles HCl = $\frac{\text{vol}}{1000} \times \text{conc} = \frac{50}{1000} \times 3$ (1)
$= 0.15$ (1) (if error here mark on conseq.)

Therefore moles of MgO reacted = moles HCl/2 (1) (mark is for /2, CE if not /2)
$= 0.15/2 = 0.075$

Therefore $\Delta H = 6.72/0.075$ (1)

$=$ -90 kJ (mol^{-1}) value (1) (kJ must be given, allow 89 to 91)
sign (1) (This mark can be given despite CE for /2)

8 marks
15 marks

Note various combinations of answers to part (c) score as follows:

-89 to -91 kJ (8) (or –89000to 91000J)	no units (7)
+89 to + 91 kJ (7) (or +89000to +91000J)	no units (6)
-44 to –46 kJ (5) (or –44000to –46000J)	no units (4) if units after 6.72 or 6720 (5)
+44 to +46 kJ (4) (or +44000to +46000J)	if no units and if no units after 6.72 or 6720 (3) otherwise check, could be (4)