2816/03 Experimental Skills 2

June 2003

Mark Scheme

The following annotations may be used when marking:

X	=	incorrect response (errors may also be underlined)
^	=	omission mark
bod	=	benefit of the doubt (where professional judgement has been used)
ecf	=	error carried forward (in consequential marking)
con	=	contradiction (in cases where candidates contradict themselves in the same response)
sf	=	error in the number of significant figures

Abbreviations, annotations and conventions used in the Mark Scheme:

/	=	alternative and acceptable answers for the same marking point
;	=	separates marking points
NOT	=	answers not worthy of credit
( )	=	words which are not essential to gain credit
___ (underlining)	=	key words which must be used
ecf	=	allow error carried forward in consequential marking
AW	=	alternative wording
ora	=	or reverse argument

A2 Practical Test - 2816/03: May 2003
Mark Scheme

Skill P 16 marks max (out of 19 available)

- **8 marks for surface area investigation**

A1 **Equation** for the reaction ***and*** name of a suitable catalyst given. [1]

$2H_2O_2 \rightarrow 2H_2O + O_2$.

*Allow any stated transition metal (or compound) **or** liver (etc) as catalyst*
No mark for a computer equation without subscripts (or smaller font figures)

A2 **Background theory**: ***Either*** *of the following explanations are acceptable*

- Explanation of how increased surface area of a catalyst speeds reaction rate
  Surface catalysis: reactant molecules are <u>weakly</u> attached/absorbed.
  Transition metals have different oxidation states
  Bonds in the reactant molecules are weakened
  Large surface area gives more active sites.
  Two *of the four ideas are required*
- Explanation of operation of catalyst related to reduction in E_A, using an energy profile diagram ***or*** a Boltzmann distribution diagram [1]

A3 **Vary surface area**: use at least **three** different masses of catalyst. [1]
Alternative idea: "use large lumps, small lumps and powder)" is OK

A4 **Fair test**: all other independent variables are kept constant, i.e.: [1]

- same volume of hydrogen peroxide for a series of experiments
- use the same temperature for each one
- same concentration of peroxide used
- same source/state of sub-division of catalyst (if different masses are used)
- same mass of catalyst (if different states of sub-division used)

Two *of these conditions must be stated or implied*

A5 **Accuracy precautions** – *accept **two** from those listed*.

- Use a constant temp. water bath to stop heat released speeding up reaction
- Repeat readings until consistent ***or*** take average
- Dilute the hydrogen peroxide before use [to make reaction slower]
- Use an inner tube (etc) inside main apparatus to separate reagents [1]

A6 **Diagram** of apparatus, neat and accurately drawn, with collection of gas [1]
Collection of gas may be by syringe, measuring cylinder or inverted burette
*If mass loss is measured, diagram must show conical **with** cotton wool plug*
Allow a good computer-generated diagram (if not too "abstract")

A7 **Measure** times taken to produce a fixed quantity of oxygen
or measure mass/volumes at various times
or measure the masses/volumes of oxygen produced in a given time [1]

A8 Rate of reaction plotted against mass of catalyst to show relationship
or rate of reaction would increase with the mass of catalyst used [1]
Mark A8 can only be awarded if candidate used a quantitative method
*Candidate **must** show clearly how the rate relates to measurements made.*
Candidate must imply that the mass and surface area are related

- ***8 marks for order determination w.r.t. H_2O_2***

Three methods are suitable

- ***B*** *– Initial rates method using different concentrations of H_2O_2*
- ***C*** *– Half life method: monitoring the decomposition by sampling at regular intervals*
- ***D*** *– Half life method: monitoring decomposition via gas volume measurement*

B – Initial rates method

B1 Use at least **four** solutions of H_2O_2 with different concentrations. [1]

B2 Some detail of accurate dilution procedure given [1]
Mention of pipettes, burettes or volumetric flasks must be included

B3 "Fair test" conditions used – **both** of the following are required:
- Use same mass of catalyst
- Same <u>volume</u> of peroxide for each experiment. [1]

B4 Two measurements required are specified [1]
- Precise concentrations of hydrogen peroxide (***or*** dilution recipes are quoted)
- Volumes of oxygen produced in the **same** length of time
or takes a series of volume readings at regular intervals

B5 Awarded for **one** of the following (*depending on the answer in B4*). [1]
- Specific statement that length of time must be short since "initial rate" is required.
- Drawing a graph of readings, then taking a tangent at time = 0 to find initial rate.

B6 **Brief e**xplanation of meaning of order of reaction [1]

B7 Gives a clear verbal explanation how to deduce the order of reaction from data. [1]

B8 Uses a sketch graph to clarify explanation of how to deduce the order [1]

C – Half life by sampling

C1 Titrates sample of hydrogen peroxide solution <u>before</u> commencing reaction [1]

C2 Add catalyst to known volume of hydrogen peroxide solution
and starts the clock/notes the start time immediately [1]

C3 Removes at least four samples of reaction mixture by pipette at regular intervals. [1]

C4 Quenches sample/adds acid to stop reaction ***and*** then measures time [1]

C5 Each sample is titrated, using $KMnO_4$ from burette [1]
or use excess KI and sodium thiosulphate
Relevant end point colour in titration is required

C6 **Brief e**xplanation of meaning of order of reaction. [1]

C7 Draws graph and uses half life concept to determine the reaction order. [1]
Deduction of half lives from a sketch graph must be shown clearly.

C8 Constant half life indicates that the reaction is first order [1]

D – Half life by monitoring gas volume

D1 [If gas volume measurement is used]: candidate calculates suitable quantity of hydrogen peroxide so that the syringe can hold all the gas liberated. [1]
Suitable volume and concentration must be worked out

D2 Outline experimental procedure described (*both ideas below required*):
- Flask connected to a gas syringe/burette
  or experiment carried out on a balance to measure mass loss
- Start timing when peroxide and catalyst are mixed [1]

D3 Measure volume/mass of gas at regular intervals using a syringe/balance [1]

D4 Measure volume (or mass) of oxygen when <u>complete</u> decomposition of the sample of hydrogen peroxide has occurred. [1]

D5 Repeat whole experiment ***and*** calculate mean masses/volumes [1]

D6 **Brief e**xplanation of meaning of order of reaction. [1]

D7 Draws graph and uses half life concept to determine the reaction order. [1]
Deduction of half lives from a sketch graph must be shown clearly.

D8 Constant half life indicates that the reaction is first order [1]

- **3 marks for Safety, Sources and QWC**

S1 Risk assessment for use of concentrated hydrogen peroxide given. [1]
*Hazard **and** specific safety measure are required for the mark*
eg "H_2O_2 is corrosive/causes skin blistering so wear gloves"
Photocopied/downloaded hazard information does not score this mark

S2 References to **two** secondary sources quoted as footnotes ***or*** at end of Plan. [1]
Book references must be specific must have chapter or page numbers
Internet reference must go beyond the first slash of web address

S3 Good QWC: between 300 and 1000 words ***and*** with word count given. [1]
Accept a word count given in multiples of 200
*QWC: allow **four** different errors in ICT, spelling **or** grammar **or** language*

A2 Practical Test (Part B)

Skills I and A 30 marks max (out of 31 available)

Page 4: Readings table – 11 marks (max)

Four readings for volumes and times given in the correct experimental number order [1]
Do not award this mark if times are recorded in minutes + seconds
Do not penalise volumes recorded 0.1 cm^3 away from integer: e.g. 7.9 cm^3 is OK

Two marks for **each** of the four readings ***if*** it is within **10%** of mean supervisor's time **[6]**
Give **one mark** for **each** reading within approx **18%** of supervisor's time.
***NB** – a **maximum** of **six marks** applies to this accuracy test*

Candidate's 10 cm^3 time (Expt 4) is between 25 - 30% of his/her own 5 cm^3 reading (Expt 2)
Award **one mark** if this time is between 20 and 35% of 5 cm^3 time **[2]**

All four $^{1000}/_{time}$ values correctly worked out, to one or 2 d.p. [1]
All Values must be correct to the final d.p. quoted

All four volume^2 values correct (*64, 25, 36, 100)* [1]

Graph (page 5) and interpretation (page 4) – 9 marks

Plotting the graph on the grid provided **[3]**

- [Initial] rate is used as the y-axis
- each axis is clearly labelled with its variable
- units are given
- the numerical scales of both axes are uniform
- plotted points use at least five large squares of the grid is used in each direction
- all four points plotted correctly

Each plotting error means one mark deducted
*Take off **one** mark for each other mistake, except for a non-uniform scale.*

Good best fit straight line drawn, through 0,0. **[3]**
*Subtract **one** mark for **each** point that is more than **0.5 cm** from best fit line*
*Award no marks for a "line" drawn without a ruler **or** if it is curved in any way*
*Maximum **one** mark if the line is **not** drawn through 0,0*

The reaction is [close to] **second** order [for iodide ions]. **[2]**
*Award **one** mark only for a guess, i.e. if there is no attempt to justify the answer*

Clear explanation of this deduction from the graph [1]
Graph shows that rate is proportional to the square of the iodide concentration

Safety (page 6) – 1 mark

Use of safety spectacles/lab coat/gloves stated ***and*** explained [1]
Both aspects are required for the mark and they must be related in the answer.

Page 7: Test tube tests – 10 marks (but 9 on Question paper)

(a)

Brown/rust precipitate/solid/suspension obtained [1]

Iron(III) hydroxide produced [1]

$Fe^{3+}(aq) + 3OH^-(aq) \rightarrow Fe(OH)_3(s)$ **[2]**

*Give **one** mark maximum if state symbols are omitted/wrong*
*Give **one** mark maximum if spectator ions are shown (on <u>both</u> sides of the equation).*

(b)

Solution is darker/redder than **K** alone (*owtte*) [1]

Blue/black/dark colour with starch [1]

[Starch is a test for] iodine produced [1]

Iod<u>ide</u> ions have been <u>oxidised</u> [to iodine] [1]

Gives correct oxidation states changes of Fe (+3 → +2) ***or*** iodine (-1 → 0)
or one correct ionic half-equation ($2I^- - 2e^- \rightarrow I_2$ ***or*** $Fe^{3+} + e^- \rightarrow Fe^{2+}$) [1]
Any one of the four options above scores the mark
If neither a half-equation nor oxidation states are given, this mark is not awarded

Iron(III) ion/ Fe^{3+} is the oxidising agent [1]

Section total is maximum 30 marks (out of 31 available)

Skill E - 14 marks maximum (out of 21 available)

"Max" is written on the script when all allowed marks have been awarded

1. 4 marks

A1 Constant total volume ensures a fair test [1]

A2 **Only** the concentration of iodide ion (**L**) must be changed during the investigation.
or concentration of iron(III) ions (**K**) must be kept constant
or there should be only one variable
or so that the volume of **L** can represent its concentration [1]

A3 If the total volume of the solution altered, $[Fe^{3+}(aq)]$ would change [1]

A4 A change in concentration of **K**, $Fe^{3+}(aq)$, would also alter the reaction rate [1]
Award of A4 is conditional on award of mark A3

2. 9 marks (max)

The best four ideas given by the candidate are marked.
Marks from this part may be awarded in question 3 (subject to max 9)

B1 **Inaccuracy/difficulty of timing the exact start of reaction.** [1]

B2 Not all **K** was added at the exact time that the timer was started (*owtte*)
or practical difficulty of adding **K** and starting clock at same time
or it takes time to ensure solutions are mixed properly [1]

B3 Sensible suggestion made (*such as those below*) to improve accuracy [1]
Get someone else to start the timer
Use a mechanical stirrer

C1 **Inaccuracy of measuring cylinders** [to measure Fe^{3+}(aq) and water] [1]

C2 Measure with a burette ***or*** graduated pipette [1]
Do <u>not</u> allow "pipette" as an alternative

C3 Burette is accurately calibrated/manufactured
or a sensible statement of tolerance of **either** piece of apparatus [1]
This mark is not given for just "a burette is more accurate".

D1 **Blue colour at end develops slowly** [in certain experiments]
or colour change at end of reaction is indistinct [1]

D2 Uncertainty about when to stop timing [for slow reactions]
or uncertainty when the reaction is "complete"/"finished"
or reference to finite human reaction time if the reaction is fast [1]

D3 Collect <u>all</u> data from experiments where the rate of reaction is quicker
or use a colorimeter/photometer [to detect blue colour] [1]

E1 **Volumes of solutions used** are [too/very] small
or use larger volumes [1]

E2 [%] Errors involved in volume measurements are large/significant [1]
*This mark is awarded in the context of small volumes **or** cumulative error*

E3 Correct quantitative attempt to work out % error for any one reading [1]

F1 **Each experiment was done only once** [1]
Any reference to repeating readings scores F1

F2 Repeat ***and*** take averages ***or*** obtain consistent times [1]

F3 This should eliminate residual/deviant/anomalous readings [1]

G1 **The volume of starch used** should be exactly the same in each experiment [1]

G2 Adding more starch would alter concentration of iron(III) ions [1]

H1 **Temperature [of solutions] may vary** [over the course of the experiments] [1]

H2 Increase of temperature would speed up the reactions/reduce the time taken [1]

H3 Keep all solutions in a constant temperature water bath [1]

3. 4 marks

Y1 Correct identification of any deviant/anomalous results on graph
or a correct implicit statement that there aren't any [1]
This mark requires a reference to the graph

Y2 Points all close to the straight line is evidence of reliability [1]
An answer show that the candidate understands significance of "reliability"

Y3 Four readings provide insufficient evidence for the conclusion [1]

Y4 A wider range of iodide ion concentrations should be used [1]

4. 4 marks

Z1 Keep volume of KI (**L**) constant for a series of readings
and vary volumes of iron(III) ion solution (**K**) used [1]

Z2 Use same experimental procedure as before, timing the blue colour [1]
Mark Z2 is conditional on a reasonable attempt at Z1

Z3 Plot graph of [initial] rate (or $^{1000}/_{time}$) against $[Fe^{3+}]$ [1]

Z4 If the graph is a straight line, the reaction is first order
or if [initial] rate is proportional to [**K**(aq)] reaction is first order [1]
This mark is not awarded for references to half life