A2 Practical 2816/03
May 2005: Mark Scheme

Planning [16 marks, max]

- *19 marking points are available*

R First stage reaction (8 marks)

R1 Adds excess of a specified iron(II)compound to a pipetted volume of aqueous Cl_2 [1]
The iron(II) compound must be soluble: oxide, carbonate and hydroxide are not suitable

R2 Equation ***or*** ionic equation for the reaction [1]
$Cl_2 + 2Fe^{2+} \rightarrow 2Cl^- + 2Fe^{3+}$

R3 Two correct redox statement(s) made about the role of chlorine in the reaction [1]
Example: "chlorine is reduced because it gains electrons"

R4/R5 **Two** ideas from those listed below, **with** the relevant comment [2]
- stir/ swirl/ heat - to speed up the reaction [of chlorine with iron(II) ions]
- leave for a while – to ensure that reaction has finished
- use a reaction vessel with a stopper - to prevent loss of chorine gas
- avoid [excessive] contact with air - to prevent any oxidation of iron(II) ions
- use fresh source of iron(II) compound - to avoid contamination with iron(III) ions
- use ammonium iron(II) sulphate – more resistant to oxidation by air
- allow for the w.o.c. in $FeSO_4.7H_2O$ in any calculation – so *Mr* = 278
- use freshly made up/recently standardised aq $KMnO_4$ – solution decomposes slowly

R6 Make mixture obtained up to (say) 250 cm^3 using a volumetric flask with pure water [1]
The mark is for outlining the procedure to make up any relevant standard solution

R7 Correct calculation of [approximate] molar concentration of saturated aqueous chlorine [1]
Approximate concentration = $^7/_{71}$ = 0.1 mol dm^{-3}

R8 Calculation of quantity of iron(II) compound needed to ensure that it is in excess [1]
*Example: 25 cm^3 of chlorine needs a **minimum** of 50 cm^3 of 0.1 mol dm^{-3} aq $FeSO_4$*

T Titration procedure (7 marks)

T1 Use known/standard solution of $KMnO_4$ for titration in the burette [1]

T2 Pipette aqueous iron(II) ions into conical flask ***and*** add [excess] sulphuric acid [1]

T3 No indicator needed for $KMnO_4$: the end point colour change is to pale purple/pink [1]

T4 First/trial titration outlined ***and*** [at least] two consistent titres obtained [1]
Within 0.05/0.1 cm^3 (unit required) is equivalent to "concordant"

T5 Equation for the titration reaction [1]
The full ionic equation is: $8H^+ + 5Fe^{2+} + MnO_4^- \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$

T6 Calculates concentration of left over Fe^{2+} ions left over in the solution being titra
or calculates number of moles of iron(II) ions left over in the solution being titra

T7 Justifies a suitable concentration of $KMnO_4$ for use in the titration [1]
The concentration needed is about one-fifth of $[Fe^{2+}]$ in the solution titrated
The explanation/calculation given must use the mole ratio from the equation

S Safety, sources and QWC (4 marks)

S1 **Chlorine** is toxic/choking/causes breathing problems
and first stage done in fume cupboard ***or*** wear gas mask ***or*** ensure that lab is well ventilated
*Hazard **and** safety measure for chlorine are both required for S1* [1]

S2 References to **two** secondary sources quoted as footnotes ***or*** at end. [1]
Book references must have page numbers
Internet references must go beyond the first slash of web address
Accept one specific reference to "Hazcards" as an alternative to either of the above

S3 **QWC**: text is legible ***and*** spelling, punctuation and grammar are accurate [1]
*Allow not more than **five** different errors in legibility, spelling, punctuation or grammar*

S4 **QWC**: information is organised clearly and coherently [1]
Is a word count given and within the limits 400 – 1000 words?
*Is scientific language used correctly? (Allow **one** error without penalty).*
Is the Plan presented in a logical easy-to-follow order?

***NB: A student who used an I_2-thiosulphate titration** to analyse chlorine has not answered the question set because this is not a back titration. The student could be awarded a maximum of 12 marks.*

A2 Practical Test (Part B)

Pages 2 + 3: Part 1 [8 marks]

(a) 3 marks

[Solution] loses yellow/orange/light brown colour [1]

[Pale] yellow/cream/cloudy/misty precipitate/suspension forms [1]
Colour and state word are both required

Iodide ions react *(name required)* [1]

(b) 1 mark

Iodine [molecules] [1]

(c) 1 mark

Species from both sides [of the equation] are present in the solution

or silver ions react with iodide ions, thereby moving the equilibrium to the right [1]

(d) 3 marks

Yellow colour removed ***or*** [solution] goes colourless [1]

NaOH (***or*** hydroxide ion) neutralizes/removes/reacts with H^+ ions ***or*** $H^+ + OH^- \rightarrow H_2O$ [1]

Equilibrium position moves to right [in eq^n 1:1], thereby removing colour/ I_2 [1]
Reference to position of equilibrium and implication are both required

Page 4: Part 2 [5 marks]

(a) 1 mark

Brown/red solution/suspension formed [1]

(b) 3 marks

The [red] colour is caused by iodine [1]

$2I^- - 2e^- \rightarrow I_2$ ***or*** $2I^- \rightarrow I_2 + 2e^-$ [1]

Iodide ions are oxidized because they lose electrons [1]
*Simple justification is required in terms of electrons (**or** oxidation state increase)*

(c) Safety: 1 mark

Peroxide is irritant/causes itching/damages skin so wash with running water [1]
Hazard and remedial action are both required

Page 7: Part 3 - Titration [10 marks]

Mass readings [1]

- Both mass readings must be listed with units shown (somewhere)
- All masses should be recorded to two (or three) decimal places
- Subtraction to give mass of **H** must be correct.
- Labelling of the masses must have minimum of the words "bottle"/"container" (*aw*)

Presentation of titration data **[2]**

- Labelled table drawn *and* used to record burette data
- Trial titre is shown *and* is labelled as such
- All "accurate" burette data are quoted to 0.05 cm^3 (i.e. 2 decimal places)
- All subtractions are correct
  A table giving only the titration differences forfeits both marks.

Self-consistency of titres [1]

Candidate's two accurate titres should agree within 0.10 cm^3.
Units, cm^3 or ml, are given somewhere (once in or alongside the table

Mean titre correctly calculated, with "cm^3 or ml" unit given

Candidate must not include the trial when calculating the mean.
*Mean should be correctly calculated and quoted to **two** d.p.*

***Accuracy* – 5 marks are available**

Write the supervisor's data (mass and mean titre) in a ring next to the candidate's table.

***Work out** what the candidate's adjusted titre **(T)** would have been if the candidate had used the same mass of **H** as the supervisor did. Then award marks as shown in the table.*

$$T = \text{candidate's mean titre} \times {}^{\text{candidate's mass}}/_{\text{supervisor's mass}}$$

T is within 0.20 cm^3 of mean supervisor's value	→	[5 marks]
T is within 0.30 cm^3 of mean supervisor's value	→	[4]
T is within 0.50 cm^3 of mean supervisor's value	→	[3]
T is within 0.70 cm^3 of mean supervisor's value	→	[2]
T is within 1.00 cm^3 of mean supervisor's value	→	[1 mark]

***Spread penalty:** If the accurate readings differ by more than 0.30 cm^3, subtract 1 mark*
Penalties for greater spreads are cumulative

Pages 8 + 9: Part 4 **[7 marks]**

- *Each answer is marked error carried forward to the previous one*
- *All answers should be given to **three** significant figures*

(a) *n*(thiosulphate) in 250 cm^3 correctly calculated = ${}^{\text{mass used}}/_{248}$ [1]

(b) *n*(thiosulphate) in mean titre, correctly calculated = ${}^{\text{"a" x mean titre}}/_{250}$ [1]
This mark is for the correct answer from candidate' mean titre.

$I_2 + 2Na_2S_2O_3 \rightarrow Na_2S_4O_6 + 2NaI$ [1]

(d) *n*[I_2] in titre = "b" x 0.5 [1]

[I_2] correctly calculated = "b" x 0.5 x 40 [1]
Answer should be about 0.050 mol dm^{-3}

(e) M_r of iodine = 254 [1]

Mass of Iodine = "d" x 254 (correctly calculated) [1]

Pages 10 + 11: Part 5 (Evaluation) **[14 marks, max]**

- *17 marking points are available*

(a) **3 marks**

Inversion mixes the solution ***or*** ensures same concentration [1]

If the concentration in the flask is not uniform, the titres will vary/not be consistent [1]

Titres would be greater [to start with] since the solution at top of the flask is more dilute [1]

(b) 2 marks

Error/tolerance on pipette is 0.06 cm^3 [1]

% error = $^{0.06}/_{25}$ x 100 = 0.24% [1]
Accept the answer 99.76/99.8 %

(c) 3 marks

Balance tolerance is 0.01 g (or 0.001 g or 0.005g) [1]

Possible error is doubled because <u>two</u> weighings are needed for **H** [1]

Balance % error = $^{0.02}/_{mass}$ x 100 = 0.33% ***and*** pipette is <u>more</u> accurate
or balance % error = $^{0.01}/_{mass}$ x 100 = 0.17% ***and*** pipette is <u>less</u> accurate [1]

(d) 2 marks

End point/colour change is sharper/ easier to see when starch is used [1]

The change from blue → colourless is clearer than yellow → colourless [1]

(e) 2 marks

It **is** reliable because the titration was repeated [1]

Titration differences were consistent/condordant ***or*** were within 0.1 cm^3
or there were no anomalous results [1]
Accept a negative statement if candidate's own readings justify it

(f) 3 marks max – *award marks for the **best** three ideas from the list below*

Back titration is more complicated/ has more stages/ uses more chemicals *(aw)*
or iodine procedure was simpler /involved fewer measurements [1]

Errors [in measurement] are **cumulative**
or just <u>one</u> extra reading doesn't make much difference [1]

Chlorine gas is more likely to escape from its solution than iodine [1]

Sodium thiosulphate is more stable than potassium manganate(VII) [1]

Burette/meniscus is difficult to read/see when using aq $KMnO_4$ [1]

(g) 2 marks

No effect on the titre because iodide ions [in KI] don't react [1]

Only iodine reacts with thiosulphate in the titration
These marks are not awarded if there is any confusion between iodine/io