**Question 1**: (a) **MnO4-(aq) + 8H+(aq) + 5Fe2+(aq)** ==> **Mn2+(aq) + 5Fe3+(aq) + 4H2O(l)**

(b) (i) mol MnO4- = 0.02 x 24.3 / 1000 = 0.000486, mol Fe2+ = 5 x 0.000486 (1 : 5 in equation) = 0.00243 in 20 cm3, so scaling up to 1 dm3, the **molarity of  Fe2+** = 0.00243 x 1000 / 20 = **0.122 mol dm-3**.

(ii) The end point is the **first faint permanent pink** due to a trace excess of KMnO4.

(c) mol MnO4- = 0.02 x 25.45 / 1000 = 0.000509, mol Fe = 5 x 0.000509 = 0.002545,

mass Fe = 0.002545 x 55.9 = 0.1423 g,

total Fe in wire = 0.1423 x 10 = 1.423 g (1/10th of the made up solution used in titration),

 so **% Fe** = 1.423 x 100 / 1.51 = **94.2 %**

(d) The choice of acid is fully discussed in [**Ex 6.4 of Advanced Redox Chemistry Part 2**](http://www.docbrown.info/page07/redox2.htm#6.4).

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 2**:(a) **2S2O32-(aq)  +  I2(aq)**  ==> **S4O62-(aq) + 2I-(aq)**

(b) mol S2O32- = 0.012 x 23.5 / 1000 = 0.000282, mole iodine as I2 = mol  S2O32- / 2 (1 : 2 in equation) = 0.000141,

**mass of iodine** = 0.000141 x 126.9 x 2 = **0.0358 g**

(c) mol S2O32- = 0.095 x 26.5 / 1000 = 0.002518,

mol of iodine = mole 'thio' / 2 = 0.002518 / 2 = 0.001259 in 25 cm3,

scaling up to 1 dm3 gives 0.001259 x 1000 /25 = **0.0504 mol dm-3 of molecular iodine I2**.

mass concentration of I2 = 0.0504 x 2 x 126.9 = **12.8 g dm-3 of iodine**

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 3**: (a) (i) **Sn2+(aq) + 2Fe3+(aq)** ==> **Sn4+(aq) + 2Fe2+(aq)**

(ii) **Cr2O72-(aq) + 14H+(aq) + 6Fe2+(aq)** ==> **2Cr3+(aq) + 6Fe3+(aq) + 7H2O(l)**

(b) for a 25cm3 aliquot titrated, mol Cr2O72- = 0.02 x 26.4 / 1000 = 0.000528,

mol Fe2+ titrated = 6 x Cr2O72- = 0.003168 (1 : 6 in equation),

mol Fe2O3 = mol Fe / 2 = 0.003168 / 2 =  0.001584,

Mr(Fe2O3) = 159.8, mass Fe2O3 = 0.001584 x 159.8 = 0.2531 g.

Total mass of Fe2O3 = 0.2531 x 10 (1/10th titrated) = 2.531 g. **% Fe2O3** = 2.531 x 100 / 2.83 **= 89.4%**

(c) Potassium manganate(VII) isn't used for this titration because it is strong enough to oxidise chloride ions (from the hydrochloric acid) to form chlorine, giving a completely false titration.

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 4**: mol Fe2+ = 0.1 x 25 / 1000 = 0.0025,

mol MnO4- = mol Fe2+ / 5 (from equation 1 : 5) = 0.0005 in 24.15 cm3,

scaling up to 1 dm3, **molarity of MnO4-** = 0.0005 x 1000 / 24.15 = **0.0207** **mol dm-3**.

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 5**: mol Cr2O72- = 0.02 x 21.25 / 1000 = 0.000425,

mol of Fe salt = mol Fe2+ titrated = 6 x Cr2O72- = 6 x 0.000425 = 0.00255,

BUT only 1/10th of Fe2+ salt used in titration,

so 1 g of FeSO4.(NH4)2S04 .**x**H2O is equal to 0.00255 mol.

Scaling up to 1 mol gives a molar mass for the salt in g mol-1 of 1 x 1 /0.00255 = 392.2.

So the formula mass for FeSO4.(NH4)2S04.**x**H2O is 392.2.

Now the formula mass of FeSO4.(NH4)2S04 = 284.1, this leaves 392.2 - 284.1 = 108.1 mass units.

Mr(H2O) = 18, so 108.1 / 18 = 6.005 mol of water, so **x = 6 in the salt formula,** FeSO4.(NH4)2S04.**6**H2O.

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 6**: (a) **2MnO4-(aq) + 16H+(aq) + 5C2O42-(aq)** ==> **2Mn2+(aq)  + 8H2O(l) + 10CO2(g)**

or **2MnO4-(aq) + 6H+(aq) + 5H2C2O4(aq)** ==> **2Mn2+(aq)  + 8H2O(l) + 10CO2(g)**

(b)  Mr(H2C2O4.2H2O) = 126.0,

total mol H2C2O4.2H2O (or C2O42-)  = 1.52 / 126 = 0.01206,

but mol of C2O42- in titration = 0.001206 (1/10th used, 25 of 250 cm3),

mol MnO4- = mol of C2O42- / 2.5 (2:5 or 1:2.5 ratio),

mol MnO4- = 0.001206 / 2.5 = 0.0004824 (in 24.55 cm3),

scaling up to 1 dm3 the **molarity of MnO4-** = 0.0004824 x 1000 / 24.55 = **0.0196 mol dm-3**.

Mr(KMnO4) = 158, so in terms of mass **concentration** = 0.0196 x 158 = **3.1 g dm-3**

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 7**: mol KHC2O4.H2C2O4.2H2O (Mr = 254.1) = 0.15 / 254.1 = 0.0005903,

ratio of tetroxalate to manganate(VII) is 2:2.5 or 1:1.25 (note equiv of 2 C2O42- in salt),

so mol MnO4- in titration = 0.0005903 / 1.25 = 0.0004723 in 23.2 cm3,

scaling up to 1 dm3 gives for **[MnO4-]** = 0.0004723 x 1000 / 23.2 = **0.0204 mol dm-3**.

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 8**: (a)  **2MnO4-(aq) + 6H+(aq) + 5H2O2(aq)**==> **2Mn2+(aq) + 8H2O(l) + 5O2(g)**

(b)  in titration mol MnO4- =  0.02 x 20.25 / 1000 = 0.000405,

MnO4-:H2O2 ratio is 2:5 or 1:2.5, so mol H2O2 in titration = 0.000405 x 2.5 = 0.0010125,

scaling up for total mol H2O2 in diluted solution (of 1 dm3 or 1000 cm3) = 0.0010125 x 1000 / 25 = 0.0405 mol,

but in the original 50 cm3 solution,

therefore scaling up to 1 dm3, the **original molarity of H2O2** is 0.0405 x 1000 / 50 = **0.81 mol dm-3**.

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 9**: (a) **Zn(s) + 2Fe3+(aq)** ==> **Zn2+(aq) +  2Fe2+(aq)**

(b) mol MnO4- in  titration = 0.01 x 26.5 / 1000 =  0.000265,

mol Fe (Fe2+) = mol MnO4- x 5 = 0.001325 in 20 cm3 of the alum solution,

scaling up gives total mol Fe = 0.001325 x 500 / 20 = 0.033125,

total mass Fe in the 13.2 g of alum = 0.033125 x 55.9 = 1.852,

so **%** **Fe =** 1.852 x 100 / 13.2 = **14.0%**

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 10**: mol MnO4- in titration = 0.05 x 24.5 / 1000 = 0.001225,

ratio MnO4-:Na2C2O4 is 2:5 or 1:2.5, so mol Na2C2O4 titrated = 0.001225 x 2.5 = 0.003063 in 5 cm3,

scaling up to 1 dm3, **molarity Na2C2O4** = 0.003063 x 1000 / 5 = **0.613  mol dm-3**

Mr(Na2C2O4) = 134, so **concentration** = 0.613 x 134 = **82.1 g dm-3**

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 11**: mol KMnO4 = 0.01 x 43.85 / 1000 = 0.0004385, mol Fe (Fe2+) = mol KMnO4 x 5,

mol Fe = 0.0004385 x 5 = 0.0021925, so mol  FeSO4.**x**H2O is also 0.0021925,

in the titration 1/20th of the salt was used (25/500), so 1/20th of 12.18 g = 0.0021925 mol of the salt = 0.609 g,

scaling up the mass of 1 mole of the salt is 0.609 x 1 / 0.0021925 = 277.8,

so formula mass of FeSO4.**x**H2O is 277.8, now the formula mass of FeSO4 is 152.0,

so the formula mass of **x**H2O = 277.8 - 152.0 = 125.8,

Mr(H2O) = 18, so x = 125.8 / 18 = 6.989,

so **x = 7** and the formula of the salt is  **FeSO4.7H2O**, i.e. seven molecules of water of crystallisation.

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 12**:  (a) **2MnO4-(aq) + 6H+(aq) + 5NO2-(aq)** ==> **Mn2+(aq) + 5NO3-(aq) +  3H2O(l)**

(b) mol KMnO4 in titration = 0.025 x 25 / 1000 = 0.000625,

mol ratio MnO4-:NO2- is 2:5 or 1:2.5, so mol NO2- in titration = 0.000625 x 2.5 = 0.0015625 in 24.2 cm3,

scaling up to 1 dm3 gives a **molar concentration of NaNO2** of  0.0015625 x 1000 / 24.2 = 0.0646 mol dm**-3**

Mr(NaNO2) = 69, so in terms of mass **concentration** = 0.0646 x 69 = **4.46 g dm-3**

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 13**: Mr(FeC2O4) = 143.9, mol FeC2O4 in original solution = 2.68 / 143.9 = 0.01862,

scaling down the mol FeC2O4 in the titration = 0.01862 x 25 / 500 = 0.000931,

mol KMnO4 in titration = 0.02 x 28.0 / 1000 = 0.00056,

so ratio KMnO4:FeC2O4 is 0.00056:0.000931 = giving the 'not so easy to spot' **3:5 the reacting mole ratio**.

FeC2O4 is made up of a  Fe2+ ion and a  C2O42- ion, and the full redox equation is:

**3MnO4-(aq)+ 5FeC2O4(aq) + 24H+(aq)**==> **3Mn2+(aq) + 5Fe3+(aq)+ 12H2O(l) + 10CO2(g)**

or **3MnO4-(aq)+ 5Fe2+(aq) + 5C2O42-(aq) + 24H+(aq)**==> **3Mn2+(aq) + 5Fe3+(aq)+ 12H2O(l) + 10CO2(g)**

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 14**: (a) **IO3-(aq) + 5I-(aq) + 6H+(aq)** ==> **3I2(aq) + 3H2O(l)**

(b) mol I- titrated = 0.100 x 20 / 1000 = 0.002, mole ratio IO3-:I- is 1:5,

so mole IO3- reacted = 0.002 / 5 = 0.0004,

so 0.0004 = 0.012 x (volume IO3- required) / 1000,

**volume IO3- required** = 0.0004 x 1000 / 0.012 = **33.3 cm3**

(c)(i) mole S2O32- ('thio') = 0.05 x 24.1 / 1000 = 0.001205,

I2:S2O32- ratio is 1:2 in the titration reaction, so mol I2 = mole S2O32- / 2 = 0.001205 / 2 = 0.0006025,

now the  IO3-:I2 reaction ratio is 1:3,

so mol IO3- reacting to give iodine = mole I2 formed / 3 = 0.0006025 / 3 = 0.000201 in 25 cm3,

so scaling up to 1 dm3 the **molarity of the KIO3** (IO3-) = 0.000201 x 1000 / 25 **= 0.00804 mol dm-3**,

 Mr(KIO3) = 214.0, so in terms of mass, **concentration** = 0.00804 x 214 **= 0.043 g dm-3**.

**A quicker approach if confident! - ratios from all equations involved are: 2S2O32- : I2 : 1/3IO3-, means that the overall mole iodate(V) = mole thiosulphate / 6, so you can 'jump' from line '1' to the last 'few' lines. However in exams these days all the stages (i.e. , to , !) are often 'broken down' for you.**

(ii) **Starch indicator** is used for the titration, when the last of the iodine reacts with the thiosulphate, the blue colour from the starch-iodine 'complex' is discharged and the solution becomes colourless.

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 15**: (i) mol KMnO4 = 0.02 x 22.5 / 1000 = 0.00045,

mol Fe2+ = mol KMnO4 x 5 = 0.00225 in 25 cm3,

scaling up to 1 dm3, **molarity of the original Fe2+** = 0.00225 x 1000 / 25 **= 0.090 mol dm-3**

(ii) the 2nd titration gives the total concentration of Fe2+ + Fe3+because any Fe3+ has been reduced to Fe2+,

mol KMnO4 = 0.02 x 37.6 / 1000 = 0.000752, total mol Fe2+ titrated = mol KMnO4 x 5 = 0.00376 in 25 cm3,

scaling up to 1 dm3, total molarity of  Fe2+ + Fe3+ in original solution = 0.00376 x 1000 / 25 = 0.150 mol dm -3,

so using the result from (a) the  **Fe3+ concentration** = 'Fe' total - Fe2+ = 0.150 - 0.090 **= 0.060 mol dm-3**.

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 16**: you can ignore the 25 cm3 of the solution because you use the same volume in each titration and you can work on the ratio of the moles of 'Fe' out of the (a) and (b) titration calculations.

(a) **mol Fe2+** = 5 x MnO4- = 5 x 0.02 x 16.9 / 1000 **= 0.00169 mol** = unreacted iron (which dissolved in the acid to form Fe2+).

(b) **mol Fe3+** = EDTA4- = 0.10 x 17.6 / 1000 **= 0.00176 mol =** total mol iron in the sample titrated.

(c) calculation (a) gives the relative moles of unreacted iron Fe, as it dissolved to form the titratable Fe2+.

Calculation (b) gives the total of unreacted Fe + the rust i.e. Fe3+, because any Fe2+ formed from Fe has been oxidised to Fe3+.

So from the original mixture (in terms of the 25 cm3 sample), mol unreacted Fe = 0.00169,

mol of reacted iron = 0.00176 - 0.00169 = 0.00007.

Therefore the % rusted iron = 0.00007 x 100 / 0.00176 = **3.98 % rusted iron**.

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 17**: (a) **I2(aq) + 2S2O32-(aq) ==> S4O62-(aq) + 2I-(aq)**

 or **I2(aq) + 2Na2S2O3(aq)** ==> **Na2S4O6(aq) + 2NaI(aq)**

(b) **Starch indicator** is used, starch gives a blue/black colour with iodine, this colour disappears when the last of the iodine is titrated, so a **blue to colourless** sharp end-point is observed.

(c) mole 'thio' = 0.1 x 17.6/1000 = 0.00176,

mol I2 = 0.00176 ÷ 2 = 0.00088 in 25 cm3,

scaling up gives 0.00088 x 1000 ÷ 25 = **0.0352 mol dm-3** for molarity of iodine,

formula mass I2 = 2 x 127 = 254, so **concentration** = 0.0352 x 254 **= 8.94 g dm-3**

[[OP sub-index & links](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm%23*)](http://www.docbrown.info/page07/SSquestions/redox_vol_calcs1ANS.htm#*)

**Question 18**: (a) **Cr2O72-(aq) + 14H+(aq) + 6I-(aq)** ==> **2Cr3+(aq) + 3I2(aq) + 7H2O(l)**

(b) **2S2O32-(aq)  +  I2(aq)**  ==> **S4O62-(aq) + 2I-(aq)**

(c) **mol 'thio'** = 20 x 0.1/1000 = **0.002**,

therefore from equation (b), **mol iodine** = mol 'thio'/2 = **0.001**

(d) From equation (a) **mol dichromate(VI)** reacting = mol iodine liberated/3 = **0.000333** (3sf)

(e) **Mr(K2Cr2O7)** = **294.2**

**mass K2Cr2O7 titrated** = 0.000333 x 294.2 =  **0.0980 g** (3 sf)

(f) Since the aliquot of 25 cm3 is 1/10th of the total solution in the flask, the **total mass** of the **K2Cr2O7** **in original sample** dissolved in the flask solution = 10 x 0.0980g = **0.98g**

and the **% purity** of the **K2Cr2O7** = 0.98 x 100/1.01 = **97.0 %** (3 sf)