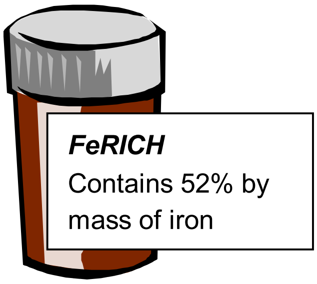
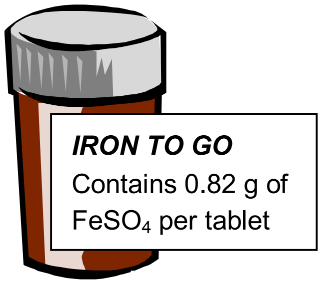
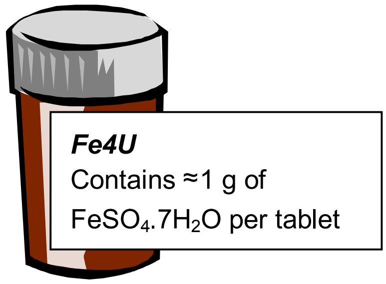
STARTER FOR 10...

13.5. Redox titrations

The pharmacists have had an accident and managed to mix up all their iron tablets. They have three foils of tablets (labelled A-C) which they know must have come from one of the bottles below;







Help the pharmacists work out which tablets are which by interpreting the results of their analyses below.

One of **Tablet A** (1.05 g) was dissolved in excess sulfuric acid and made up to 250 cm^3 in a volumetric flask. A 25.00 cm^3 aliquot of this solution required 21.65 cm^3 of a 0.005 mol dm^{-3} solution of $KMnO_4$ for complete oxidation.

....

....

.... **Tablet A is from** .... (3 marks)

2.10 g of **Tablet B** (2 tablets) were dissolved in excess sulfuric acid and made up to 500 cm^3 in a volumetric flask. A 25.00 cm^3 aliquot of this solution required 19.45 cm^3 of a 0.010 mol dm^{-3} solution of $KMnO_4$ for complete oxidation.

....

....

.... **Tablet B is from** .... (3 marks)

One of **Tablet C** (1.21 g) was dissolved in excess sulfuric acid and made up to 500 cm^3 in a volumetric flask. A 20.00 cm^3 aliquot of this solution required 10.5 cm^3 of a 0.0022 mol dm^{-3} solution of $K_2Cr_2O_7$ for complete oxidation.

....

....

.... **Tablet C is from** .... (3 marks)

BONUS MARK How could you check that all of the iron in the ***FeRICH*** tablets is in the form of iron(II) and not iron(III)? (1 mark)

STARTER FOR 10...

13. Transition metal chemistry answers

2. Key features of the experiment described include;

1. Initially the sample of E133 of known concentration must be diluted with water to produce dilute samples of known concentration. Five or more solutions must be produced. Possible dilutions would be;

Vol. of 0.20 mol dm^{-3} solution of E133 / cm^3	Vol. of water added	New conc. of solution of E133 / mol dm^{-3}	Absorbance
10	0	0.20	
8	2	0.16	
6	4	0.12	
4	6	0.08	
2	8	0.04	
0	10	0.00	

2. Measure the absorbance of each new known concentration of E133 and record these results in a suitable table.
3. Plot a calibration graph of concentration of E133 (x-axis) against absorbance (y-axis).
4. Measure the absorbance of the sports drink '*Go, go, go.*'
5. Use the calibration graph plotted in 3. to determine the concentration of E133 in '*Go, go, go.*'

(5 marks)

13.5. Redox titrations

Tablet A

$5\,Fe^{2+} + MnO_4^- + 8\,H^+ \rightarrow 5\,Fe^{3+} + Mn^{2+} + 4\,H_2O$

No. of moles in 21.65 cm^3 of 0.005 mol dm^{-3} $KMnO_4$ = 1.08×10^{-4} mol

Therefore, no. of moles of Fe^{2+} in 25.00 cm^3 aliquot = (1.08×10^{-4} mol) × 5 = 5.41×10^{-4} mol

Therefore, no. of moles of Fe^{2+} in 250 cm^3 and hence in one of Tablet A = (5.41×10^{-4} mol) × 10

= 5.41×10^{-3} mol *(1 mark)*

Molar mass of $FeSO_4$ = 151.9 g mol^{-1}

Therefore mass of $FeSO_4$ per tablet = 5.41×10^{-3} mol × 151.9 g mol^{-1} = 0.82 g *(1 mark)*

Therefore Tablet A comes from the ***IRON TO GO*** pack. *(1 mark)*

Tablet B

$5\,Fe^{2+} + MnO_4^- + 8\,H^+ \rightarrow 5\,Fe^{3+} + Mn^{2+} + 4\,H_2O$

No. of moles in 19.45 cm^3 of 0.010 mol dm^{-3} $KMnO_4$ = 1.945×10^{-4} mol

Therefore, no. of moles of Fe^{2+} in 25.00 cm^3 aliquot = (1.08×10^{-4} mol) × 5 = 9.725×10^{-4} mol

Therefore, no. of moles of Fe^{2+} in 500 cm^3 and hence in two of Tablet B = (9.725×10^{-4} mol) × 20

= 0.01945 mol *(1 mark)*

Mass of iron in two tablets of B = 0.01945 mol × 55.8 g mol^{-1} = 1.085 g *(1 mark)*

Therefore the % by mass of iron in Tablet B = (1.085 g / 2.10 g) × 100% = 51.6 %
Therefore Tablet B comes from the ***FeRICH*** tablets. *(1 mark)*

Tablet C

$6\,Fe^{2+} + Cr_2O_7^{2-} + 14\,H^+ \rightarrow 6\,Fe^{3+} + 2\,Cr^{3+} + 7\,H_2O$

No. of moles in 10.5 cm^3 of 0.0022 mol dm^{-3} $K_2Cr_2O_7$ = 2.31×10^{-5} mol

Therefore, no. of moles of Fe^{2+} in 20.00 cm^3 aliquot = (2.31×10^{-5} mol) × 6 = 1.386×10^{-4} mol

Therefore, no. of moles of Fe^{2+} in 500 cm^3 and hence in one of Tablet C = (1.386×10^{-4} mol / 20) × 500
= 3.465×10^{-3} mol *(1 mark)*

Molar mass of $FeSO_4.7H_2O$ = 151.9 + (7 × 18.0) = 277.9 g mol^{-1}

Therefore mass of $FeSO_4.7H_2O$ per tablet = 3.465×10^{-3} mol × 277.9 g mol^{-1} = 0.96 g *(1 mark)*

Therefore Tablet C comes from the ***Fe4U*** tablets. *(1 mark)*

BONUS MARK

Either

Add an excess of zinc to a 25.0 cm^3 aliquot of the original solution. This will reduce any Fe^{3+} ions to Fe^{2+} ions. Filter off the unreacted zinc and titrate the mixture against $KMnO_4$. If the titre is the same (i.e. the amount of $KMnO_4$ needed for complete oxidation has not changed) then only Fe^{2+} ions were present in the original solution. If the titre has increased (i.e. more $KMnO_4$ is needed for complete oxidation) then the original sample must have contained some Fe^{3+} ions.

or

Dissolve the tablet in water and add sodium hydroxide solution until present in excess. If Fe^{2+} is present a green precipitate of $[Fe(H_2O)_4(OH)_2]$ would form. Any Fe^{3+} present would form an orange/brown precipitate of $[Fe(H_2O)_3(OH)_3]$.

(1 mark for either method)

13.6. Redox chemistry of transition metals

1. (a)

reduction →

	VO_2^+	VO^{2+}	V^{3+}	V^{2+}
Oxid^n state	+5	+4	+3	+2

← oxidation

(1 mark for correct oxidation states, 1 mark for correct identification of oxidation and reduction)

(b) (i) The electrode potentials for the V^{3+}/V^{2+} electrode and the VO^{2+}/V^{3+} electrode are each more negative that the NO_3^-/NO electrode potential. Therefore, NO_3^- will initially oxidise V^{2+} to V^{3+}