Chemguide – answers

TRANSITION METALS: MANGANESE

1. a) $[Mn(H_2O)_6]^{2+}$

   b) The very very pale pink (virtually colourless) solution of manganese(II) sulphate produces a pale brown precipitate which darkens to a dark brown around the top.

   c) $[Mn(H_2O)_4(OH)_2]$

   d) The precipitate is being oxidised by the air to give manganese(III) oxide.

2. a) The solution containing the deep purple manganate(VII) ion first turns very dark green, forming the manganate(VI) ion and is then reduced further to give a black precipitate of manganese(IV) oxide.

   b) It is too strong an oxidising agent, and tends to break carbon-carbon bonds.

   c) ethane-1,2-diol: $HOCH_2CH_2OH$

   (You could equally well use the form of the structure shown in the equation on the Chemguide page.)

   d) In both cases, the product is benzoic acid.

3. a) A primary standard is a substance that you can make up a solution of with an accurately known concentration. The solution is also stable, and doesn't change in any way on standing. Potassium manganate(VII) is so dark coloured that it is impossible to be sure that all the crystals you are trying to dissolve have actually dissolved. The potassium manganate(VII) also oxidises the water it is dissolved in over time, and so its concentration changes.

   b) $(COOH)_2 \longrightarrow 2CO_2 + 2H^+ + 2e^-$

   (There is no reason why you can't draw the two COOH groups separately showing the bond between the two carbons as in the corresponding equation on the Chemguide page. Don't waste time learning this – it is trivial to work out.)

   c) $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$

   (This is such a common half-equation that it is almost worth learning it, although it is easy to work out, provided you know that Mn^{2+} ions are formed.)

d)

$$5 \times ((COOH)_2 \longrightarrow 2CO_2 + 2H^+ + 2e^-)$$

$$2 \times (MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O)$$

$$2MnO_4^- + \underline{16H^+} + 5(COOH)_2 \longrightarrow 2Mn^{2+} + 8H_2O + 10CO_2 + \underline{10H^+}$$

. . . but notice that you have hydrogen ions on both sides – so simplify it:

$$2MnO_4^- + 6H^+ + 5(COOH)_2 \longrightarrow 2Mn^{2+} + 8H_2O + 10CO_2$$

e) Start from what you know most about. You don't know the exact concentration of the potassium manganate(VII) – that's what you are trying to find. So start with the ethanedioic acid.

$$\text{number of moles of } (COOH)_2 = \frac{25}{1000} \times 0.0500$$

The equation shows that you only need 2/5 as many moles of manganate(VII) ions as of ethanedioic acid.

$$\text{number of moles of } MnO_4^- = \frac{2}{5} \times \frac{25}{1000} \times 0.0500 \quad \text{in } 25.7 \text{ cm}^3$$

$$\text{concentration of } MnO_4^- = \frac{1000}{25.7} \times \frac{2}{5} \times \frac{25}{1000} \times 0.0500$$
$$= 0.0195 \text{ mol dm}^{-3}$$

Is this a sensible answer? Yes – you know the solution will be somewhere about 0.02 mol dm^{-3} because the question said so.

Comments:

You could, of course, work out intermediate answers if you are more comfortable with doing that, but if you do, don't over-round them. Your final answer has to be to 3 significant figures, because that's the accuracy of the numbers you are working with. So any intermediate answers should be written down to at least 4 significant figures.

It may be that you have been taught using other ways of doing titration calculations – perhaps by slotting numbers into some sort of formula that you have learnt. Personally, I would never use such methods, however quick they may appear in simple cases like this one. They work OK for standard cases, but since there is a risk that you don't really *understand* what you are doing, things can go badly wrong for you in more complicated cases.

If your maths is very weak and you can't see easily why, for example, you had to multiply by 1000/25.7 in the last stage, add another step. If there were some number of moles in 25.7 cm^3, how many would there be in 1 cm^3? (Divide by 25.7) How many would there be in 1000 cm^3? (Multiply that answer by 1000.) You could think the first line of the calculation through in the same way.