TRANSITION METALS: COPPER

1. a) Reagent A: ammonia solution complexes formed: middle tube: $[Cu(H_2O)_4(OH)_2]$
last tube: $[Cu(NH_3)_4(H_2O)_2]^{2+}$

b) Reagent B: sodium hydroxide solution complex formed: $[Cu(H_2O)_4(OH)_2]$

Reagent C: sodium carbonate solution compound formed: $CuCO_3$

(These answers could, of course, equally well be the other way around, so that B could be the sodium carbonate solution. Also the reactions would be identical if you used potassium rather than sodium compounds.)

c) Reagent D: potassium iodide solution compound formed: CuI

(There is CuI in both of the tubes containing product. It is produced as a precipitate in a solution of iodine, and takes some time to settle. Sodium iodide would produce the same result.)

d) Reagent E: concentrated hydrochloric acid complex formed: $[CuCl_4]^{2-}$

(There is still unchanged $[Cu(H_2O)_4(OH)_2]$ present in the tube because the reaction is reversible.)

2. a) This is a redox reaction. The copper has been reduced from a +2 oxidation state to +1. The iodine has been oxidised from a -1 oxidation state to the zero oxidation state in the element.

(Trying to explain this in terms of electron transfer is a bit more of a bother because you would have to construct electron-half-equations. I suppose you might also describe this as a precipitation reaction because a precipitate is formed. That misses the point! The important thing here isn't the formation of the precipitate, but the change of oxidation state.)

b) (i)

$$\text{moles of } Na_2S_2O_3 = \frac{22.5}{1000} \times 0.100$$
$$= 0.00225$$

(You could equally well record this as 2.25×10^{-3}, because that's the way it will appear on your calculator if you used one.)

(ii) $$2S_2O_3{}^{2-}{}_{(aq)} + I_{2(aq)} \longrightarrow S_4O_6{}^{2-}{}_{(aq)} + 2I^-{}_{(aq)}$$

2 moles of thiosulphate ions (from 2 moles of sodium thiosulphate) react with 1 mole of iodine. That 1 mole of iodine came from 2 moles of copper(II) ions reacting.

$$2Cu^{2+}{}_{(aq)} + 4I^-{}_{(aq)} \longrightarrow 2CuI_{(s)} + I_{2(aq)}$$

So overall, the number of moles of copper(II) ions is the same as the number of moles of sodium thiosulphate that you used: 0.00225 moles

(iii) There were 0.00225 moles of copper(II) ions in 25 cm^3 of the solution you started with – so work out the concentration of the copper(II) ions in mol dm^{-3}. The concentration of the copper(II) sulphate solution is, of course, the same as the concentration of copper(II) ions.

$$\text{concentration of } CuSO_4 = 0.00225 \times \frac{1000}{25}$$
$$= 0.0900 \text{ mol dm}^{-3}$$

3. a) The difference is that copper(I) iodide and copper(I) chloride are both insoluble in water, and so produced as solids. Copper(I) sulphate would be soluble in water, and so would produce a solution containing copper(I) ions and sulphate ions. But copper(I) ions undergo disproportionation in solution to give copper(II) ions and a precipitate of copper.

That means that any attempt to produce copper(I) sulphate ends up producing copper(II) sulphate and copper.

b) (i) $[CuCl_2]^-$

(ii) Add water which removes the extra chloride ion and leaves CuCl as a precipitate. The precipitate has to be separated and dried quickly to prevent it disproportionating.