HL Answers to questions on Electrochemical cells (2) (AHL) - Electrolysis

1. i. 500 cm^3. Since 4 mol of electrons are required to form one mol of oxygen and only 2 mol of electrons are required to form 1 mol of hydrogen twice the amount (and hence twice the volume) of hydrogen will be produced.

ii. $2H^+(aq) + 2e^- \rightarrow H_2(g)$ and $Pb^{2+}(l) + 2e^- \rightarrow Pb(l)$ so the same amount of lead (in mol) will be formed as hydrogen produced.
Amount of hydrogen = 500/22700 = 0.0220 mol; A_r for Pb = 207.20
Mass of lead = 0.0220 x 207.20 = 4.56 g

iii. It would have no effect. The cells were connected in series so the same quantity of electricity passed through both cells.

2. i. With graphite electrodes copper is deposited at the (–) electrode: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ and oxygen is evolved at the (+) electrode: $2H_2O(l) \rightarrow 4H^+(aq) + O_2(g) + 4e^-$
With copper electrodes, copper is still deposited at the (–) electrode but the (+) electrode reacts to produce copper ions and electrons so no gas is evolved: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

ii. With graphite electrodes the intensity of the blue colour decreases and the solution eventually goes colourless as all the aqueous copper ions (which cause the blue colour) are deposited as copper. With copper electrodes the intensity of the blue colour remains constant as each copper ion that is deposited as copper metal is replaced by a copper ion going into solution from the positive electrode.

3. Make the piece of steel the negative electrode and ideally make the positive electrode from a piece of pure silver. During the electrolysis the silver ions will be reduced (and deposited as silver on the steel electrode) in preference to hydrogen ions from the water as they are above hydrogen in the electrochemical series. The equation is : $Ag^+(aq) + e^- \rightarrow Ag(s)$

4. i. (–) electrode (cathode): $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ (or $2H^+(aq) + 2e^- \rightarrow H_2(g)$)
(+) electrode (anode): $2H_2O(l) \rightarrow 4H^+(aq) + O_2(g) + 4e^-$

ii. (–) electrode (cathode): $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ (or $2H^+(aq) + 2e^- \rightarrow H_2(g)$)
(+) electrode (anode): $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ (mainly - although some oxygen will also still be evolved.)

5. Both give two volumes of hydrogen, formed at the negative electrode (cathode), to every one volume of oxygen, formed at the positive electrode (anode). i.e. H_2O. Pure water itself is a poor conductor of electricity but the ions in the NaOH(aq) or $H_2SO_4(aq)$ cause the 'water' to conduct.