Redox Equilibria

① Find the emfs of the following cells:

a) $Al_{(s)} | Al^{3+}_{(aq)} || Cd^{2+}_{(aq)} | Cd_{(s)}$
b) $Ag_{(s)} | Ag^{+}_{(aq)} || Cu^{2+}_{(aq)} | Cu_{(s)}$
c) $Pt_{(s)} | Fe^{2+}_{(aq)}, Fe^{3+}_{(aq)} || Cl_{2(g)}, 2Cl^{-}_{(aq)} | Pt_{(s)}$

Values ($E^{\ominus}$)
$Al^{3+}/Al = -1.66$ volts
$Cd^{2+}/Cd = -0.40$ volts
$Ag^{+}/Ag = +0.80$ volts
$Cu^{2+}/Cu = +0.34$ volts
$Fe^{3+}/Fe^{2+} = +0.77$ volts
$Cl_2/2Cl^{-} = +1.36$ volts

② Calculate the unknown $E^{\ominus}$ values from $E^{\ominus}_{cell}$ and the $E^{\ominus}$ given values below:

a) Cr^{3+}/Cr if $E^{\ominus}_{cell} = -0.49$ volts for $Ni_{(s)} | Ni^{2+}_{(aq)} || Cr^{3+}_{(aq)} | Cr_{(s)}$
b) V^{3+}/V^{2+} if $E^{\ominus}_{cell} = -2.11$ volts for $Pt_{(s)} | V^{2+}_{(aq)}, V^{3+}_{(aq)} || Mg^{2+}_{(aq)} | Mg_{(s)}$
c) Mn^{2+}/Mn if $E^{\ominus}_{cell} = +0.79$ volts for $Mn_{(s)} | Mn^{2+}_{(aq)} || Cd^{2+}_{(aq)} | Cd_{(s)}$

Values ($E^{\ominus}$)
$Ni^{2+}/Ni = -0.25$ volts
$Mg^{2+}/Mg = -2.37$ volts
$Cd^{2+}/Cd = -0.40$ volts

③ Which of the following reactions are feasible?

a) $3Co^{2+}(aq) + 2Al(s) \longrightarrow 3Co(s) + 2Al^{3+}(aq)$

b) $2Na^{+}(aq) + Mg(s) \longrightarrow 2Na(s) + Mg^{2+}(aq)$

c) $2Br^{-}(aq) + Cl_2(g) \longrightarrow Br_2(l) + 2Cl^{-}(aq)$

Values ($E^{\ominus}$)
$Al^{3+}/Al = -1.66$ volts
$Co^{2+}/Co = -0.28$ volts
$Na^{+}/Na = -2.71$ volts
$Mg^{2+}/Mg = -2.37$ volts
$Br_2/2Br^{-} = +1.07$ volts
$Cl_2/2Cl^{-} = +1.36$ volts
$Fe^{3+}/Fe^{2+} = +0.77$ volts

④ Potassium Manganate (VII) solution acidified with dilute sulphuric acid, and potassium dichromate (VI) solution acidified with dilute sulphuric acid are both oxidising agents. Are either, or both, strong enough to oxidise chloride ions to chlorine?

$Cl_2(g) + 2e^{-} \rightleftharpoons 2Cl^{-}(aq)$ $\quad E^{\ominus} = +1.36$ volts

$MnO_4^{-} + 8H^{+}(aq) + 5e^{-} \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$ $\quad E^{\ominus} = +1.51$ volts

$Cr_2O_7^{2-}(aq) + 14H^{+}(aq) + 6e^{-} \rightleftharpoons 2Cr^{3+}(aq) + 7H_2O(l)$ $\quad E^{\ominus} = +1.33$ volts

(5) Water can be oxidised to oxygen according to the equation

$$2H_2O \longrightarrow O_2 + 4H^+_{(aq)} + 4e^-$$

Given the following $E^\ominus$ values, what can you use to oxidise water in this way?

$MnO_4^-{}_{(aq)} + 8H^+_{(aq)} + 5e^- \rightleftharpoons Mn^{2+}_{(aq)} + 4H_2O_{(l)}$	$E^\ominus = +1.51$ volts
$Cl_2 + 2e^- \rightleftharpoons 2Cl^-_{(aq)}$	$E^\ominus = +1.36$ volts
$Cr_2O_7^{2-}{}_{(aq)} + 14H^+_{(aq)} + 6e^- \rightleftharpoons 2Cr^{3+}_{(aq)} + 7H_2O_{(l)}$	$E^\ominus = +1.33$ volts
$O_{2(g)} + 4H^+_{(aq)} + 4e^- \rightleftharpoons 2H_2O_{(l)}$	$E^\ominus = +1.23$ volts
$Br_{2(l)} + 2e^- \rightleftharpoons Br^{2-}{}_{(aq)}$	$E^\ominus = +1.07$ volts