Chemguide – questions

MAKING PREDICTIONS USING REDOX POTENTIALS

1. In each of the following cases decide whether the reaction is feasible. You don't need to explain how you arrived at the decision, but to count it as right, it must be more than a guess!

a) The reaction between zinc and lead(II) nitrate solution.

$$Pb^{2+}_{(aq)} + 2e^- \rightleftharpoons Pb_{(s)} \qquad E^0 = -0.13\ v$$

$$Zn^{2+}_{(aq)} + 2e^- \rightleftharpoons Zn_{(s)} \qquad E^0 = -0.76\ v$$

b) The reaction between copper and silver nitrate solution.

$$Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)} \qquad E^0 = +0.34\ v$$

$$Ag^{+}_{(aq)} + e^- \rightleftharpoons Ag_{(s)} \qquad E^0 = +0.80\ v$$

c) The reduction of vanadium(III) ions to vanadium(II) ions by metallic tin.

$$V^{3+}_{(aq)} + e^- \rightleftharpoons V^{2+}_{(aq)} \qquad E^0 = -0.26\ v$$

$$Sn^{2+}_{(aq)} + 2e^- \rightleftharpoons Sn_{(s)} \qquad E^0 = -0.14\ v$$

d) The reduction of vanadium(III) ions to vanadium(II) ions by metallic zinc.

$$V^{3+}_{(aq)} + e^- \rightleftharpoons V^{2+}_{(aq)} \qquad E^0 = -0.26\ v$$

$$Zn^{2+}_{(aq)} + 2e^- \rightleftharpoons Zn_{(s)} \qquad E^0 = -0.76\ v$$

e) The reduction of acidified dichromate(VI) ions to chromium(III) ions using iron(II) ions.

$$Cr_2O_7^{2-}{}_{(aq)} + 14H^+_{(aq)} + 6e^- \rightleftharpoons 2Cr^{3+}_{(aq)} + 7H_2O_{(l)} \qquad E^0 = +1.33\ v$$

$$Fe^{3+}_{(aq)} + e^- \rightleftharpoons Fe^{2+}_{(aq)} \qquad E^0 = +0.77\ v$$

f) The oxidation of iron(II) ions to iron(III) ions by the air under acidic conditions.

$$Fe^{3+}_{(aq)} + e^- \rightleftharpoons Fe^{2+}_{(aq)} \qquad E^0 = +0.77\ v$$

$$O_{2(g)} + 4H^+_{(aq)} + 4e^- \rightleftharpoons 2H_2O_{(l)} \qquad E^0 = +1.23\ v$$

g) The oxidation of lead(II) ions to lead(IV) oxide by the air under acidic conditions.

$$PbO_{2(s)} + 4H^+_{(aq)} + 2e^- \rightleftharpoons Pb^{2+}_{(aq)} + 2H_2O_{(l)} \qquad E^0 = +1.47\ v$$

$$O_{2(g)} + 4H^+_{(aq)} + 4e^- \rightleftharpoons 2H_2O_{(l)} \qquad E^0 = +1.23\ v$$

h) The oxidation of lead(II) oxide to lead(IV) oxide by the air under alkaline conditions.

$$PbO_{2(s)} + H_2O_{(l)} + 2e^- \rightleftharpoons PbO_{(s)} + 2OH^-_{(aq)} \qquad E^0 = +0.28\ v$$

$$O_{2(g)} + 2H_2O_{(l)} + 4e^- \rightleftharpoons 4OH^-_{(aq)} \qquad E^0 = +0.40\ v$$

2. (Don't be put off by the fact that this next bit of chemistry is likely to be unfamiliar to you. The whole point of redox potentials is that you can use them to make predictions about reactions you have never met.)

   Vanadium has a number of different oxidation states including +4 and +5. In the +4 oxidation state it forms the ion VO^{2+}. In the +5 oxidation state, it forms the ion VO_2^+. The redox potential for the change is

   $$VO_2{}^+{}_{(aq)} + 2H^+{}_{(aq)} + e^- \rightleftharpoons VO^{2+}{}_{(aq)} + H_2O_{(l)} \quad E^0 = +1.00\text{ v}$$

   Using *only* the half-reactions listed in Q1, list everything that you could use to oxidise VO^{2+} to VO_2^+. Be precise about this. Write down exactly what you would use to oxidise VO^{2+} ions to VO_2^+.

3. Manganese(IV) oxide doesn't react with dilute (1 mol dm^{-3}) hydrochloric acid, but oxidises concentrated (10 mol dm^{-3}) hydrochloric acid to chlorine. Explain these observations using the following standard redox potentials.

   $$MnO_{2(s)} + 4H^+{}_{(aq)} + 2e^- \rightleftharpoons Mn^{2+}{}_{(aq)} + 2H_2O_{(l)} \quad E^0 = +1.23\text{ v}$$

   $$Cl_{2(g)} + 2e^- \rightleftharpoons 2Cl^-{}_{(aq)} \quad E^0 = +1.36\text{ v}$$

4. In some cases, the standard redox potentials suggest that a reaction is feasible, and yet it doesn't happen in the lab. Suggest a reason why that might be.