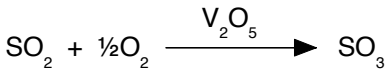
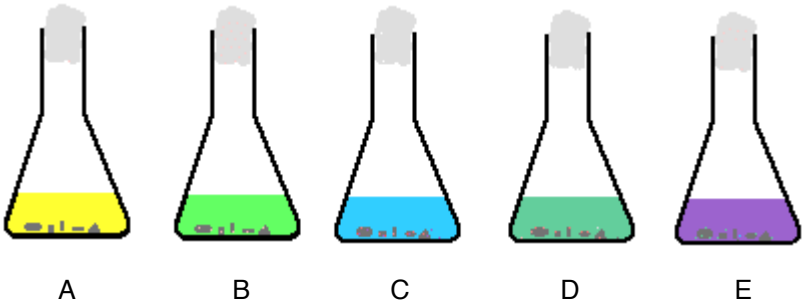
TRANSITION METALS: VANADIUM

1. The central reaction in the Contact Process for the manufacture of sulphuric acid is



where the vanadium(V) oxide functions as a catalyst. The reaction happens in two steps which depend on the vanadium's ability to vary its oxidation state. Write equations for those two steps.

2. If you warm a solution of ammonium metavanadate with zinc and moderately concentrated hydrochloric acid, the vanadium is reduced through its range of oxidation states. The mixture is warmed in a flask stoppered with cotton wool. The solution goes through these colour changes:



Solution A contains the VO_2^+ ion. Other ions which are formed are $V(H_2O)_6^{3+}$, $V(H_2O)_6^{2+}$ and VO^{2+}.

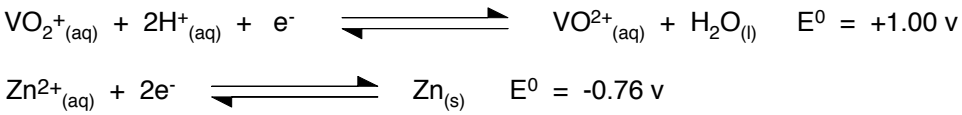
a) What are the oxidation states of the vanadium in the ions VO_2^+, $V(H_2O)_6^{3+}$, $V(H_2O)_6^{2+}$ and VO^{2+}.

b) Which are the main ions present in the flasks B, C, D, and E?

c) Describe and explain what happens if you pour the liquid contents of flask E into another container.

Don't waste time looking at the rest of the questions unless you are reasonably confident about redox potentials. If you *should* be confident, but *aren't*, go and sort out that topic before you continue with this one.

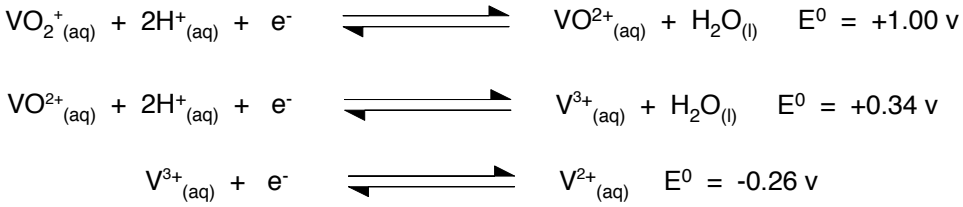
3. The E^0 values for the equilibria involved in the reduction of VO_2^+ to VO^{2+} are



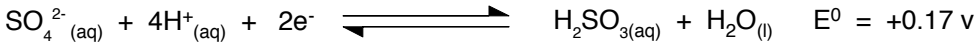
a) Explain how the given E^0 values show that you can use zinc as a reducing agent in this reaction.

b) Work out the ionic equation for the overall reaction.

4. The E^0 values for all the stages of the reduction of VO_2^+ are as follows.



Sulphur dioxide is a reducing agent, and dissolves in water to form sulphurous acid, H_2SO_3. When it reduces something, it forms sulphate ions. The E^0 value for the change is given by



If you treated VO_2^+ ions with sulphur dioxide under acidic conditions, what colour would the final solution be? Explain your answer.