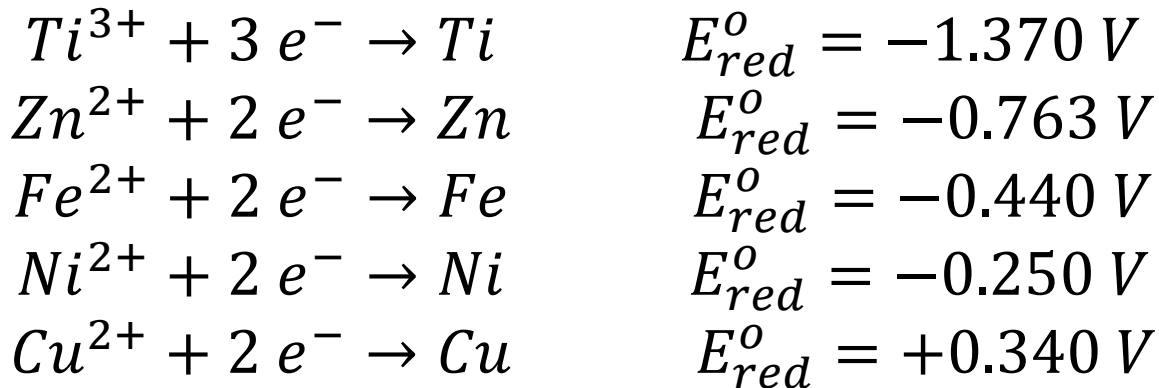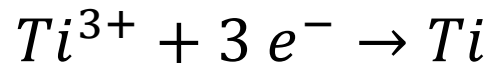# Reduction of hydronium to form H_2

Write balanced redox reactions for the reduction of hydronium ion to hydrogen gas by the following metals. Which of the metals below will reduce H^+ to H_2 at pH 7?

$$Ti^{3+} + 3\,e^- \rightarrow Ti \qquad E^o_{red} = -1.370\,V$$
$$Zn^{2+} + 2\,e^- \rightarrow Zn \qquad E^o_{red} = -0.763\,V$$
$$Fe^{2+} + 2\,e^- \rightarrow Fe \qquad E^o_{red} = -0.440\,V$$
$$Ni^{2+} + 2\,e^- \rightarrow Ni \qquad E^o_{red} = -0.250\,V$$
$$Cu^{2+} + 2\,e^- \rightarrow Cu \qquad E^o_{red} = +0.340\,V$$

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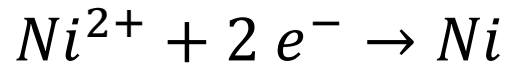
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Solution: The SHE is

$$2\,H^+ + 2\,e^- \rightarrow H_2 \qquad E^o_{red} = +0.0\,V$$

To obtain the reduction potential at pH 7 we write the Nernst equation for the half cell reaction.

$$E_{red} = E^o_{red} - \frac{RT}{nF} \ln \frac{P_{H_2}}{[H^+]^2}$$

Reduction of hydronium to form H_2

Write balanced redox reactions for the reduction of hydronium ion to hydrogen gas by the following metals. Which of the metals below will reduce H^+ to H_2 at pH 7? Substituting in the values we find:
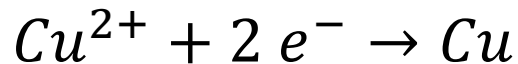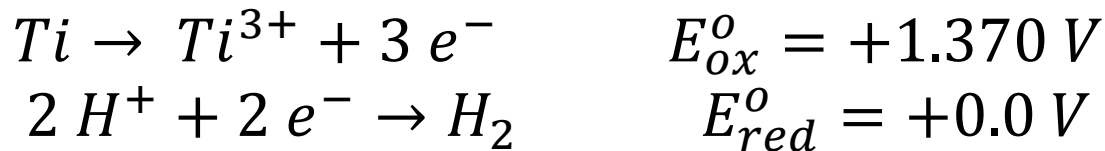
$$E_{red} = -\frac{(8.31)(298)}{(2)(96472)} \, ln \frac{1}{[10^{-7}]^2}$$

$$E_{red}(pH\ 7) = -0.414\ V$$

We first examine the reaction with titanium. The Ti reaction is the oxidation

$$Ti \rightarrow Ti^{3+} + 3\ e^- \qquad E^o_{ox} = +1.370\ V$$
$$2\ H^+ + 2\ e^- \rightarrow H_2 \qquad E^o_{red} = +0.0\ V$$

Fined the least common factor

$$2(Ti \rightarrow Ti^{3+} + 3\ e^-) \qquad E^o_{ox} = +1.370\ V$$
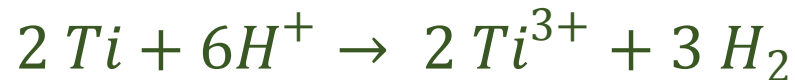$$3(2\ H^+ + 2\ e^- \rightarrow H_2) \qquad E^o_{red}(pH\ 7) = -0.413\ V$$

Reduction of hydronium to form H_2

Write balanced redox reactions for the reduction of hydronium ion to hydrogen gas by the following metals. Which of the metals below will reduce H^+ to H_2 at pH 7? The balanced reaction with Ti is

$$2\,Ti + 6H^+ \rightarrow\ 2\,Ti^{3+} + 3\,H_2$$

and the cell potential is:

$$E^o_{red} + E^o_{ox} = E^o_{cell}$$

$$(-0.413\,V) + 1.370 = +0.957\,V$$

This reaction will occur in the direction it is written. We use the same procedure for the other metals to find:

$$Zn + 2\,H^+ \rightarrow Zn^{2+} + H_2 \qquad E^o_{cell} = +0.350$$

$$Fe + 2\,H^+ \rightarrow Fe^{2+} + H_2 \qquad E^o_{cell} = +0.027$$

$$Ni + 2\,H^+ \rightarrow Ni^{2+} + H_2 \qquad E^o_{cell} = -0.163$$

$$Cu + 2\,H^+ \rightarrow Cu^{2+} + H_2 \qquad E^o_{cell} = -0.753$$

Reduction of hydronium to form H_2

Write balanced redox reactions for the reduction of hydronium ion to hydrogen gas by the following metals. Which of the metals below will reduce H^+ to H_2 at pH 7?

We conclude that Ti, Zn and Fe can reduce H^+ to H_2 at pH, but Ni and Cu cannot.