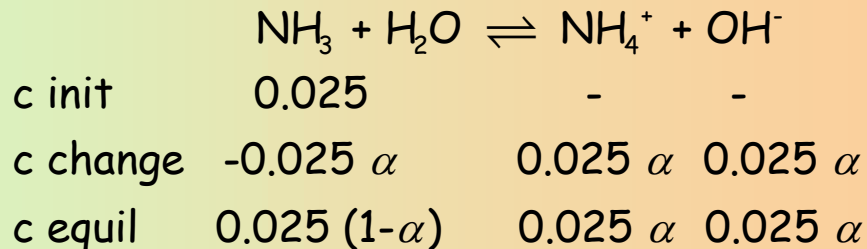


Acid-Base and Redox Exam - Solutions

Exercise #1

The reaction table is:



a) The dissociation percent

From the dissociation constant we get the dissociation percent:

$$K_b = 1.8 \cdot 10^{-5} = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]} = 0.025 \frac{\alpha^2}{1-\alpha} \xrightarrow[1-\alpha=1]{\text{approximation}} \rightarrow$$

$$\alpha = \sqrt{\frac{1.8 \cdot 10^{-5}}{0.025}} = 0.0268 \rightarrow \text{Approximation correct} \rightarrow \alpha = 2.68 \%$$

b) The number of moles of hydroxide ions

$$n(\text{OH}^-) = [\text{OH}^-] \cdot V = (0.025 \alpha) \cdot 0.1 \text{ L}$$

$$n(\text{OH}^-) = 6.7 \cdot 10^{-5} \text{ mol OH}^-$$

Acid-Base and Redox Exam - Solutions

c) pH

First, we will calculate pOH and then pH:

$$\text{pOH} = -\log(0.025 \alpha) = 3.17$$

$$\text{pH} = 14 - \text{pOH} = 10.83$$

d) The volume of HCl in neutralization

The reaction is: $\text{NH}_3 + \text{HCl} \rightarrow \text{NH}_4\text{Cl}$

1 mol 1 mol

36.5 g

$$\text{Mm}(\text{HCl}) = 1 + 35.5 = 36.5 \text{ g/mol}$$

The amount of ammonia neutralized is:

$$n(\text{NH}_3) = 0.025 \frac{\text{mol}}{\text{L}} * 0.1 \text{ L} = 2.5 * 10^{-3} \text{ mol NH}_3$$

The volume of HCl will be:

$$V(\text{HCl}) = 2.5 * 10^{-3} \text{ mol NH}_3 * \frac{1 \text{ mol HCl}}{1 \text{ mol NH}_3} * \frac{36.5 \text{ g HCl}}{1 \text{ mol HCl}} * \frac{1 \text{ L}}{25 \text{ g HCl}} = 3.65 * 10^{-3} \text{ L}$$

$$V = 3.65 \text{ mL HCl solution}$$

Acid-Base and Redox Exam - Solutions

Exercise #2

a) Molarity

We are going to transform one way to express concentrations into another:

$$\text{Mm}(\text{HNO}_3) = 1 + 14 + (3 \cdot 16) = 63 \text{ g/mol}$$

$$[\text{HNO}_3] = \frac{40 \text{ g HNO}_3}{100 \text{ g sol}} * \frac{1250 \text{ g sol}}{1 \text{ L sol}} * \frac{1 \text{ mol}}{63 \text{ g HNO}_3} = 7.94 \text{ M}$$

b) pH

This acid is strong; it means that it is fully dissociated. Thus:

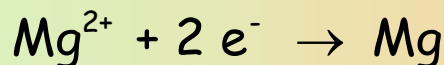
$$\text{pH} = -\log(7.94) = -0.9$$

The acid is so concentrated that the pH is negative.

Acid-Base and Redox Exam - Solutions

Exercise #3

a) Mass 96500 C are the equivalent of 1 mole of electrons.
Magnesium is reduced according to this half-reaction:



The charge that passes through the cell in 3.5 days is:

$$q = 6.20 \frac{\text{C}}{\text{s}} * 3.5 \text{ days} * \frac{24 \text{ hr}}{1 \text{ day}} * \frac{3600 \text{ s}}{1 \text{ hr}} = 1\,874\,880 \text{ C}$$

The mass of Mg formed:

$$m = 1\,874\,880 \text{ C} * \frac{1 \text{ mol } e^{-}}{96\,500 \text{ C}} * \frac{1 \text{ mol Mg}}{2 \text{ mol } e^{-}} * \frac{24 \text{ g Mg}}{1 \text{ mol Mg}} = 233.15 \text{ g Mg}$$

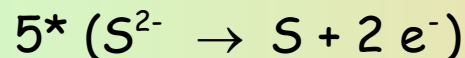
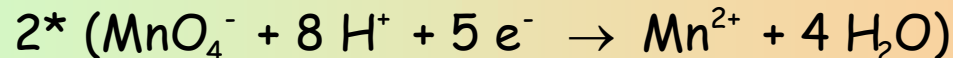
b) Time (in minutes) The time needed:

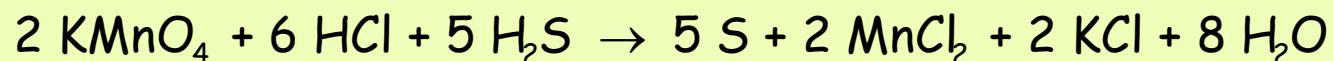
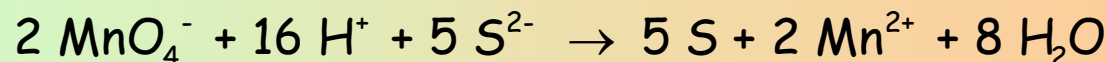
$$t = 10 \text{ g Mg} * \frac{1 \text{ mol Mg}}{24 \text{ g Mg}} * \frac{2 \text{ mol } e^{-}}{1 \text{ mol Mg}} * \frac{96\,500 \text{ C}}{1 \text{ mol } e^{-}} * \frac{1 \text{ s}}{4.5 \text{ C}} * \frac{1 \text{ min}}{60 \text{ s}} = 297.8 \text{ min}$$

Acid-Base and Redox Exam - Solutions

Exercise #4

a) Balancing the equation





b) The species

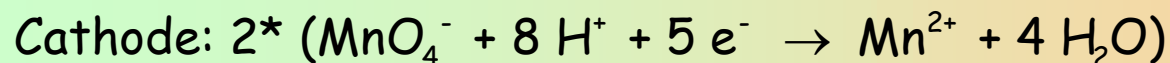
Oxidant: MnO_4^-

Reduced: Mn^{2+}

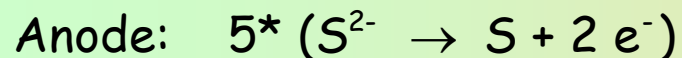
Reductant: S^{2-}

Oxidized: S

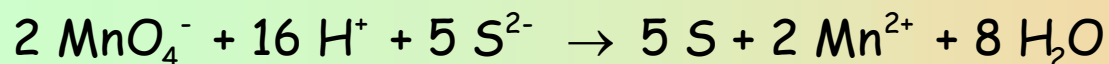
c) d) The voltaic cell



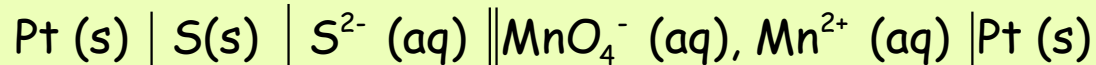
$$E^0 = 1.51 \text{ V}$$



$$E^0 = -0.14 \text{ V}$$



$$E_{\text{cell}}^0 = 1.37 \text{ V}$$



Acid-Base and Redox Exam - Solutions

Exercise #5

a) Natural acidic rain

It is the acidic rain produced by CO_2 in the atmosphere. It is weakly acidic (pH = 5.6)

b) Gas emissions

Nitrogen (NO_x) and sulfur oxides (SO_x) are the gases responsible for the acid rain.

c) Effects in lakes

It kills living organisms (pH is acidic) and liberates heavy metal ions from rocks.

d) Prevention

Catalytic converters (eliminates NO_x) and combustion of fuels with low content in sulfur.