

# APPENDIX TITRATION GUIDE

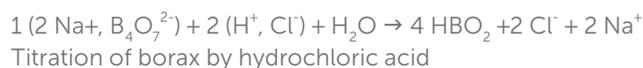
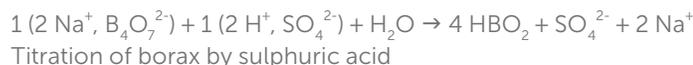
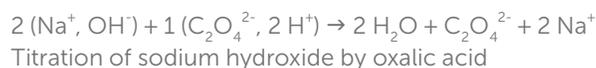
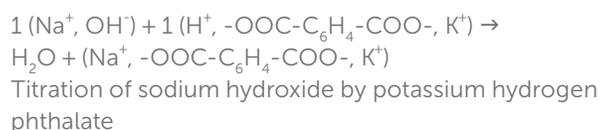
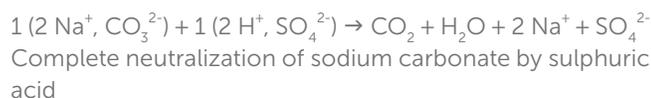
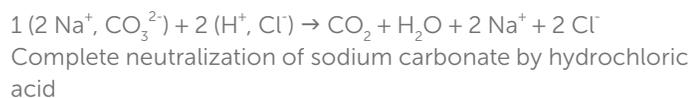
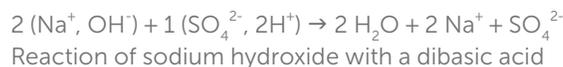
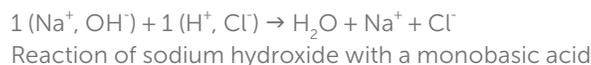
## Color changes of some color indicators in pH measurement

Methyl orange (helianthine)	pH 3.1 to pH 4.4
Bromophenol blue	pH 3.0 to pH 4.0
Bromocresol green	pH 4.0 to pH 5.6
Methyl red	pH 4.2 to pH 6.2
Bromothymol blue	pH 6.2 to pH 7.6
Phenolphthalein	pH 8.0 to pH 10.0

## Equations of some titration reactions

The syntax below is used to show the relationship between titrant and analyte during the reaction which helps explain the stoichiometry of the reactions.

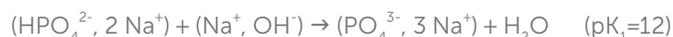
### Acid/base reactions



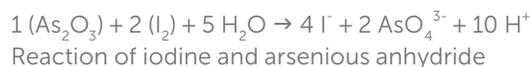
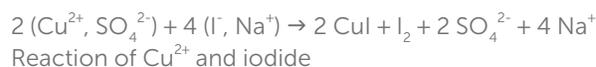
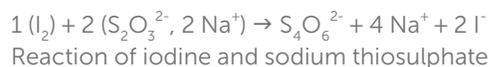
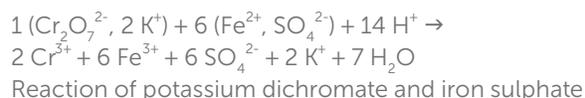
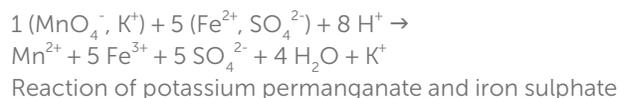
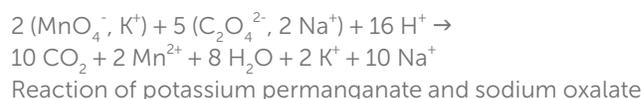
### Example of phosphoric acid $\text{H}_3\text{PO}_4$

This is a triacid with the following pKs:  
 $\text{pK}_3=2.1$ ,  $\text{pK}_2=7.2$  and  $\text{pK}_1=12$

In an aqueous medium, only the first two acids can be titrated.  
The reactions are as follows:



### Redox reactions



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## Complexometric reactions

The most common complexing agent used is disodium salt of ethylenediaminetetraacetic acid, or EDTA, usually expressed in its simple form as  $H_2Y^{2-}$ .

As it is often used to complex divalent metals of the  $Me^{2+}$  type, the reaction is written as follows:



## Precipitation reactions

The most important use of precipitation reactions is silver nitrate used to titrate halides ( $Cl^-$ ,  $Br^-$ ,  $I^-$ ) and  $CN^-$  and  $SCN^-$  used to titrate  $Ag^+$  ions.

For halides, the reaction is as follows:



Some other reactions correspond to the precipitation of usually divalent metal hydroxides:



## Characteristics of some standards

We consider a standard to be a commercially available substance of sufficient purity, delivered with a certificate. Such a standard can be weighed to make stable solutions.

### pH standards

Oxalic acid  $(COOH)_2, 2 H_2O$   
MW=126.03 g/mol

Potassium hydrogen phthalate  $KOOC-C_6H_4-COOH$   
MW= 204.22 g/mol

Sodium carbonate  $Na_2CO_3$   
MW=105.99 g/mol

TRIS or THAM  $H_2N-C(CH_2OH)_3$   
MW=121.14 g/mol

Sodium borate (Borax)  $Na_2B_4O_7, 10 H_2O$   
MW=381.4 g/mol

## Redox standards

Oxalic acid  $(COOH)_2, 2 H_2O$   
MW=126.03 g/mol

Potassium dichromate  $K_2Cr_2O_7$   
MW=294.19 g/mol

Ferrous ammonium sulphate (Mohr's salt)  $(NH_4)_2SO_4, FeSO_4, 6 H_2O$   
MW=392.14 g/mol

Arsenious anhydride  $As_2O_3$   
MW=169.87 g/mol

Potassium iodate  $KIO_3$   
MW=213.97 g/mol

## Complexometric standards

Disodium salt of EDTA  $Na_2H_2Y, 2 H_2O$   
MW=372.24 g/mol

## Precipitation standards

Silver nitrate  $AgNO_3$   
MW=169.87 g/mol

Potassium chloride  $KCl$   
MW=74.56 g/mol

Sodium chloride  $NaCl$   
MW=58.44 g/mol

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