

## § Acid-base titration

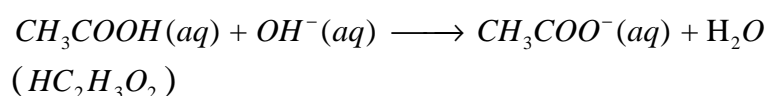
Titration : Measuring the volume of a standard solution (a solution of known concentration) required to react with a measured amount of sample.

Fig 4.7 titration of vinegar ( $CH_3COOH$ ) with sodium hydroxide

Step 1. 三角錐瓶加入已知量之  $CH_3COOH$  + 指示劑 (1-2 drop)

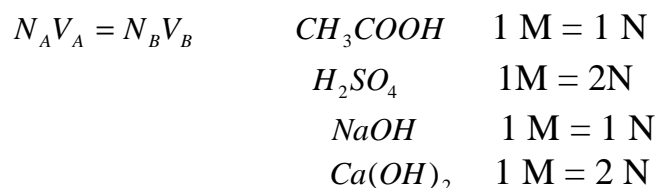
Step 2. 以滴定管滴入  $NaOH$  酸管：全玻璃  
鹼管：玻璃 + 塑膠軟件

Step 3. 滴定至滴定終點



### Equivalence point : 當量點

The number of equivalent mole of base equal to the number of equivalent mole of acid .



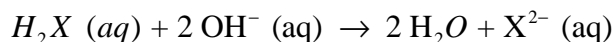
### End point : 滴定終點

The point of the indicator change color.

### Neutralization point : 中和點

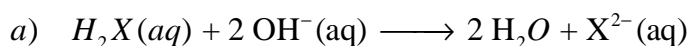
The titration solution reaches  $pH = 7.0$ .

§ Ex 4-7 : Three beakers labeled A, B, and C contain the weak acid  $H_2X$ . The weak acid is titrated with 0.125 M NaOH. Assume the reaction to be



- Beaker A contains 25.00 mL of 0.316 M  $H_2X$  . What volume of NaOH is required for complete neutralization?
- Beaker B contains 25.0 mL of a solution of  $H_2X$  and requires 28.74mL of NaOH for complete neutralization. What is the molarity of the  $H_2X$  solution?
- Beaker C contains 0.124 g of  $H_2X$  and **25.00 ML of water**. To reach the equivalence point, 22.04 mL of NaOH are required. What is the molar mass of  $H_2X$ ?

Ans:



$$n_{H_2X} = \frac{25.00}{1000} \cdot 0.316 = 7.90 \times 10^{-3} \text{ mol}$$

$$n_{H_2X} : n_{OH^-} = 1 : 2$$

$$7.90 \times 10^{-3} : n_{OH^-} = 1 : 2$$

$$n_{OH^-} = 0.0158 \text{ mol}$$

$$V_{OH^-} = \frac{n_{OH^-}}{M_{OH^-}} = \frac{0.0158}{0.125} = 0.126 \text{ L}$$

$$b) \quad n_{OH^-} = 0.125 \times \frac{28.74}{1000} = 3.59 \times 10^{-3} \text{ mol}$$

$$n_{H_2X} : n_{OH^-} = 1 : 2$$

$$n_{H_2X} : 3.59 \times 10^{-3} = 1 : 2$$

$$n_{H_2X} = 1.80 \times 10^{-3} \text{ mol}$$

$$M_{H_2X} = \frac{n_{H_2X}}{V_{H_2X}} = \frac{1.80 \times 10^{-3}}{0.02500} = 0.0720 \text{ M}$$

$$c) \quad n_{OH^-} = 0.125 \times \frac{22.04}{1000} = 2.76 \times 10^{-3} \text{ mol}$$

$$n_{H_2X} : n_{OH^-} = 1 : 2$$

$$n_{H_2X} : 2.76 \times 10^{-3} = 1 : 2$$

$$n_{H_2X} = 1.38 \times 10^{-3} \text{ mol}$$

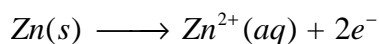
$$MM_{H_2X} = \frac{m_{H_2X}}{n_{H_2X}} = \frac{0.124}{1.38 \times 10^{-3}} = 89.9 \text{ g/mol}$$

## § 4-4 Oxidation-reduction Reactions $\Rightarrow$ Redox reactions

$\hookrightarrow$  involves a transfer of electrons between two species.

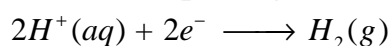
例：金屬與酸之反應 Zn 與 HCl 反應

Oxidation : a specie loses electrons



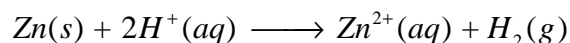
$\hookrightarrow$  The ion or molecule donates electrons  $\Rightarrow$  Reducing agent

Reduction : a specie gains electrons



$\hookrightarrow$  The ion or molecule accepts electrons  $\Rightarrow$  Oxidizing agent

Redox reaction :



For a redox reaction :

1. Oxidation and reduction occur together.
2. There is no net change in the number of electrons in a redox reaction.

## § Oxidation number 氧化數

	Oxidation number	Ex.
1. An element in an elementary substance	0	$\text{Cl}_2$ 0 $\text{P}_4$ 0 K    0
2. Monatomic ion	the charge of the ion	$\text{Cl}^-$ -1 $\text{Al}^{3+}$ +3 $\text{O}^{2-}$ -2
3. IA element in compound	+1	$\text{Na}^+$ +1 $\text{K}^+$ +1
IIA	+2	$\text{Ca}^{2+}$ +2 $\text{Mg}^{2+}$ +2
VIIA	-1	$\text{Cl}^-$ -1 $\text{F}^-$ -1
Oxygen in ordinary compound	-2	$\text{H}_2\text{O}$ O : -2
	例外 :	$\text{H}_2\text{O}_2$ O : -1
Hydrogen in ordinary compound	+1	$\text{HCl}$ H : +1
	例外 :	$\text{NaH}$ H : -1 $\text{CaH}_2$ H : -1

4. The sum of the oxidation numbers in a neutral species is 0.

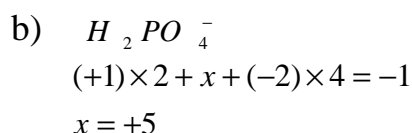
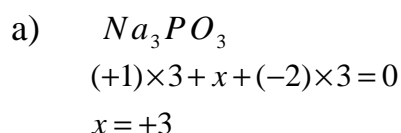
5. In a polyatomic ion, it is equal to the charge of that ion.

Ex 4-8 : What is the oxidation number of phosphorus in

a) sodium phosphite,  $\text{Na}_3\text{PO}_3$  ?

b) In the dihydrogen phosphate ion  $\text{H}_2\text{PO}_4^-$  ?

Ans:

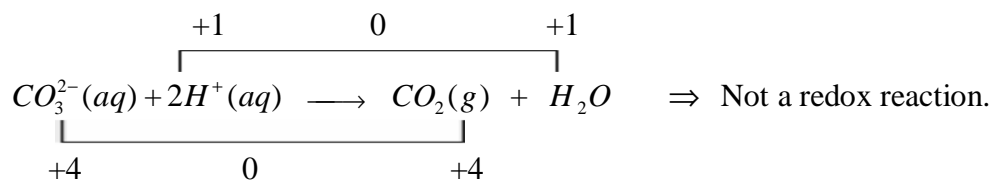
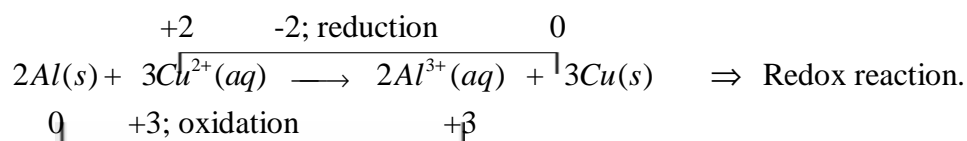
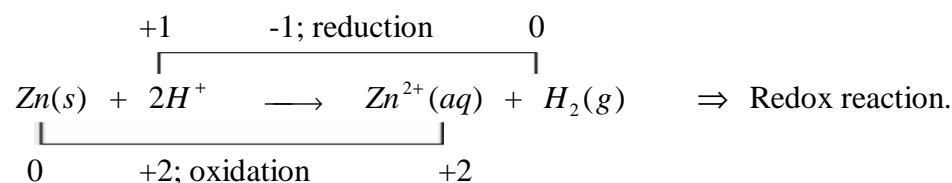


## § Oxidation and Reduction

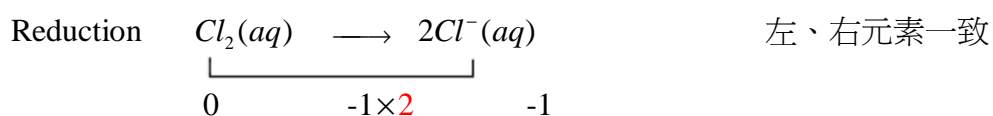
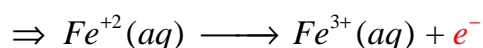
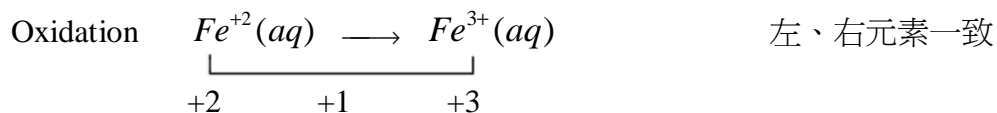
(陽極)

Oxidation : an increase in oxidation number 氧化數增加,失去電子,還原劑

Reduction : a decrease in oxidation number 氧化數減少,獲得電子,氧化劑  
 (陰極)



## § Balancing half-equation (Oxidation or Reduction)





若是:



平衡步驟：

a. Balance the atoms of the element being oxidized or reduced.

b. Balance the oxidation number by adding electrons.

平衡氧化數: 氧化數多的一邊加電子

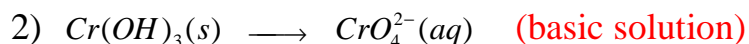
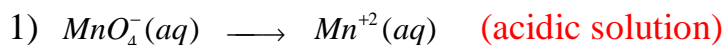
c. Balance charge by adding  $H^+$  ions in acidic solution,  $OH^-$  ions in basic solution.

平衡電荷數: 酸溶液加  $H^+$  (電荷數較少之一邊), 鹼溶液加  $OH^-$  (電荷數較多之一邊)

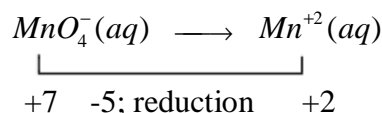
d. Balance hydrogen by adding  $H_2O$  molecules. 平衡 H: **H** 不夠一邊加  $H_2O$

e. Balance Oxygen number. 平衡 O: **O** 左右相等即完成平衡

Ex 4-9 : Balance the following half-equations

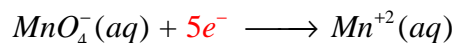


Sol : 1) a)  $x + (-2) \times 4 = -1 \Rightarrow x = +7$



b) 氧化數多的一邊加  $e^-$

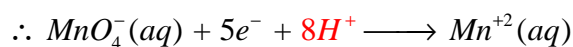
$\therefore$  左:  $+5e^-$



c) 酸溶液加  $H^+$  (電荷數較少之一邊)

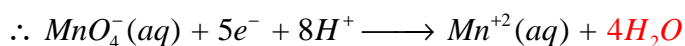
電荷數: 左: -6                  右: +2

$\therefore$  左:  $+8H^+$

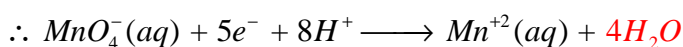


d) H: 左 = 8                  右 = 0

$\therefore$  右:  $+4H_2O$

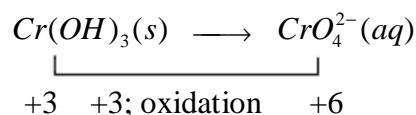


e) O : 左 = 4      右 = 4      ok!!



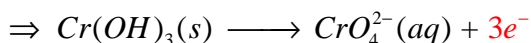
B)

a)  $x + (-2) \times 4 = -2 \Rightarrow x = +6$



b) 氧化數多的一邊加  $e^-$

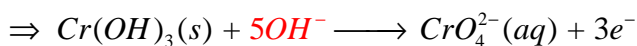
$\therefore$  右 :  $+3e^-$



c) 鹼溶液加  $\text{OH}^-$  (電荷數較多之一邊)

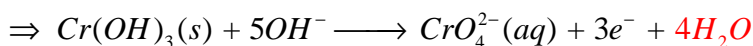
電荷數: 左 : 0      右 :  $-2 - 3 = -5$

$\therefore$  左 :  $+5\text{OH}^-$

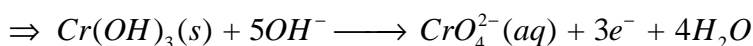


d) check H : 左 =  $3+5$       右 = 0

右 :  $+4\text{H}_2\text{O}$



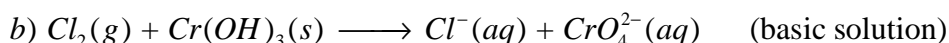
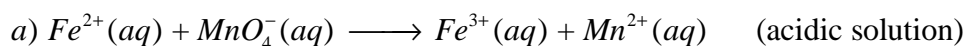
e) check O : 左 =  $3 + 5 = 8$       右  $4 + 4 = 8$  ok!!



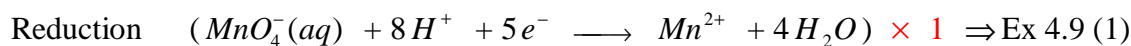
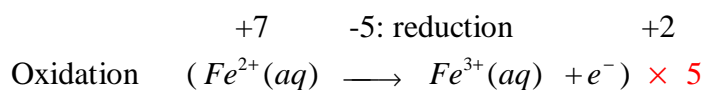
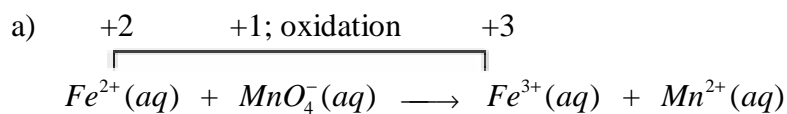
## § Balancing Redox equation:

1. 分爲 oxidation 及 reduction equation
2. 分別平衡 half-equation
3. 分別平衡另一 half-equation
4. (2 + 3)  $\Rightarrow$  消去電子

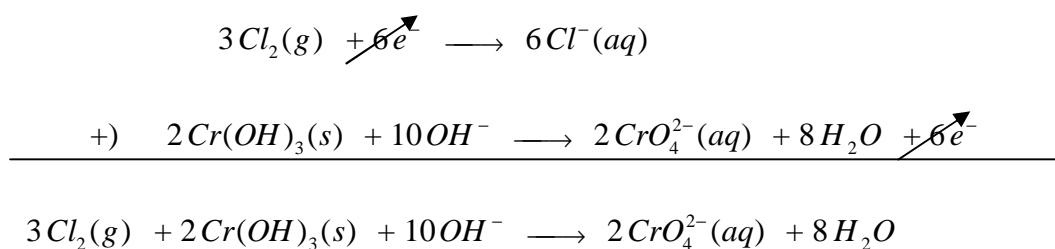
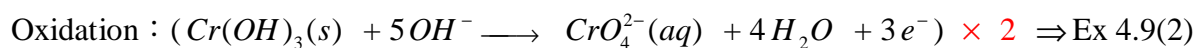
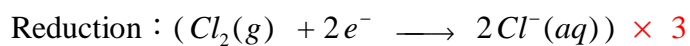
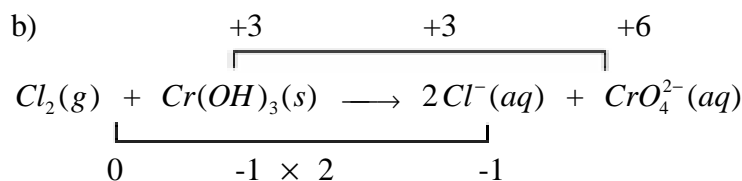
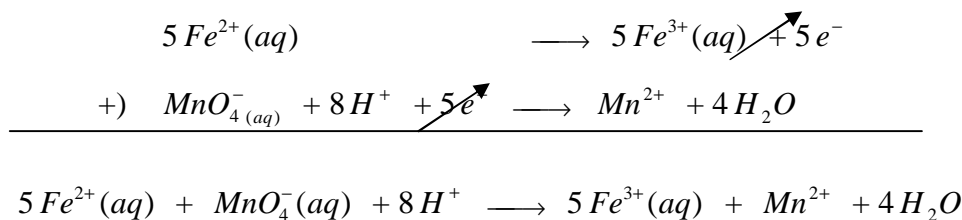
Ex 4-10 : Balance the following redox equations.



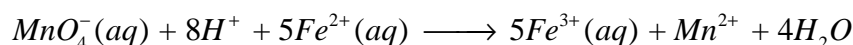
Ans:



$\Rightarrow$



Ex 4-11: As you found in Example 4.10, the balanced equation for the reaction between  $MnO_4^-(aq)$  and  $Fe^{2+}(aq)$  in acidic solution is



What volume of 0.684 M  $KMnO_4$  solution is required to react completely with 27.5 mL 0.250 M  $Fe(NO_3)_2$  ?

Ans:

$$n_{Fe^{2+}} = 0.250 \times \frac{27.5}{1000} = 6.88 \times 10^{-3} \text{ mol}$$

$$1 : 5 = n_{MnO_4^-} : 6.88 \times 10^{-3}$$

$$n_{MnO_4^-} = 1.38 \times 10^{-3} \text{ mol}$$

$$1.38 \times 10^{-3} = 0.684 \times \frac{x}{1000}$$

$$x = 2.02 \text{ mL}$$