

Balancing Reaction Equations Oxidation State Reduction-oxidation Reactions

OCN 623 – Chemical Oceanography

Balanced chemical reactions are the **math** of chemistry

They show the **relationship** between the reactants and the products

We will use thermodynamics later on to calculate the **feasibility** of reactions and to understand how equilibrium is established

The concept of **equilibrium** allows us to understand chemical processes such as ionic speciation, oxidation state distributions, gas solubility, the carbonate system

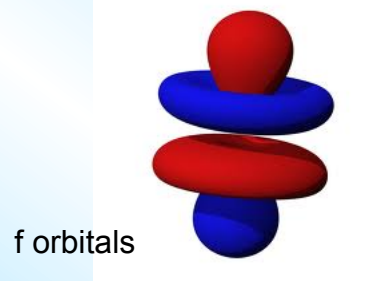
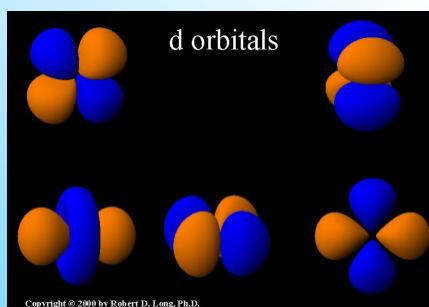
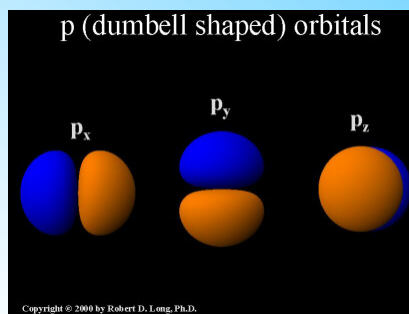
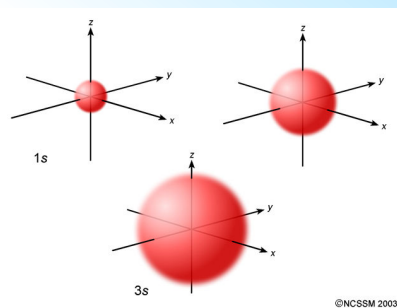
A. Oxidation state or number

Oxidation: **Loss** of electrons from an element.
Oxidation number **increases**

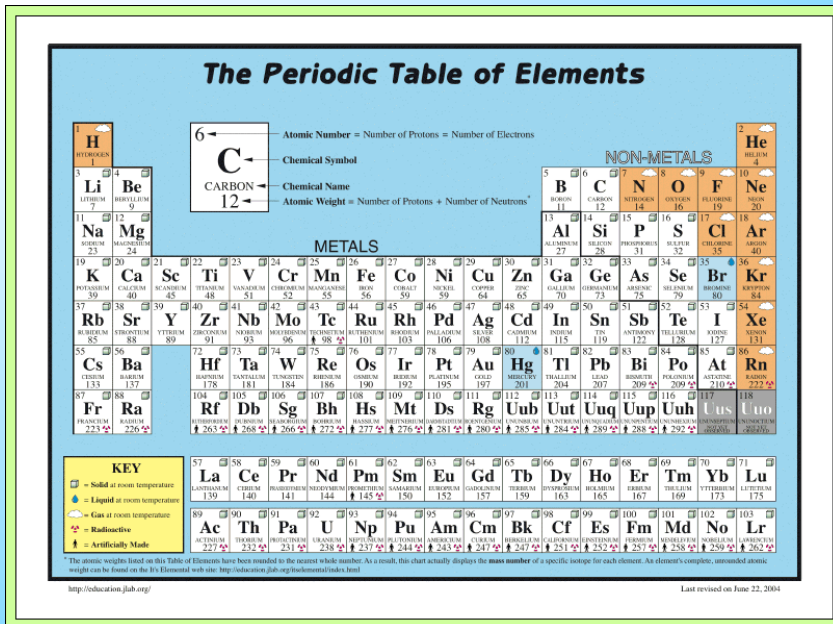
Reduction: **Gain** of electrons by an element.
Oxidation number **decreases**

If we want to determine whether reaction is oxidation or reduction

Need to know **oxidation number** of the element and how it changes



Element	Electron Configuration
Hydrogen	1s ¹
Helium	1s ²
Lithium	1s ² 2s ¹
Beryllium	1s ² 2s ²
Boron	1s ² 2s ² 2p ¹
Carbon	1s ² 2s ² 2p ²
Nitrogen	1s ² 2s ² 2p ³
Oxygen	1s ² 2s ² 2p ⁴
Fluorine	1s ² 2s ² 2p ⁵
Neon	1s ² 2s ² 2p ⁶
Sodium	1s ² 2s ² 2p ⁶ 3s ¹
Magnesium	1s ² 2s ² 2p ⁶ 3s ²
Aluminium	1s ² 2s ² 2p ⁶ 3s ² 3p ¹
Silicon	1s ² 2s ² 2p ⁶ 3s ² 3p ²
Phosphorus	1s ² 2s ² 2p ⁶ 3s ² 3p ³
Sulfur	1s ² 2s ² 2p ⁶ 3s ² 3p ⁴
Chlorine	1s ² 2s ² 2p ⁶ 3s ² 3p ⁵
Argon	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶



Rules for determining oxidation number of an element

1. Oxidation state of an element in its elementary state = 0

e.g. Cl_2 , Na, P,....etc.

2. Oxidation state of an element in a monatomic (only one atom) ion is equal to the charge on the ion

e.g. $\text{Na}^+ = +1$; $\text{Cl}^- = -1$; $\text{Fe}^{3+} = +3$

3. Oxidation state of certain elements is the same in all, or almost all of their compounds

e.g. Group 1A elements: Li, Na, K, Rb, Cs = +1

Group 2A elements: Be, Mg, Ca, Sr, Ba, Ra = +2

Group VII b elements: F, Cl, Br, I, At = -1 in binary compounds

Oxygen is almost always -2 (Except: when bonded to O or F)

H is almost always +1; Except with a metal, e.g. NaH, CaH_2 is -1

4. The sum of the oxidation states in a neutral species is = 0;

In a charged ion it is equal to the charge on the ion

e.g. Na_2Se : Na = $+1 \times 2 = 2$, thus Se = -2

MnO_4^- : O = $-2 \times 4 = -8$, thus Mn = $8 - 1 = 7$

5. **Fractional oxidation numbers are possible.** *E.g.*, in $\text{Na}_2\text{S}_4\text{O}_6$ (*sodium tetrathionate*), S has an oxidation number of $+10/4$:

$$\text{O: } 6(-2) = -12$$

$$\text{Na: } 2(+1) = 2$$

Residual = -10, which must be balanced by S:

$$\text{S: } 4(+10/4) = +10$$

6. **The oxidation number is designated by:**

- Arabic number below the atom, or
- Roman numeral or Arabic number after the atom (in parentheses)

What is the oxidation state of the elements in KNO_3 ?

K = ?; O = ?; N = ?

$\text{K}_2\text{Cr}_2\text{O}_7$? K = ?; O = ?, Cr = ?

Oxidation is an increase in oxidation state

e.g. Cl^- to Cl_2 is -1 to 0

Reduction is a decrease in oxidation state

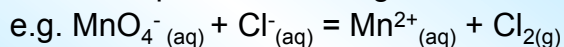
SO_4^{2-} to H_2S is a reduction S VI to S -II

Recognising oxidation/reduction

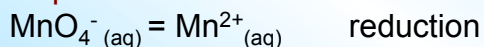
KMnO_4 to MnO_2 oxidation or reduction?

B. Balancing oxidation-reduction reactions

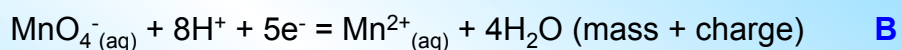
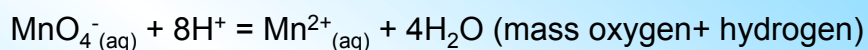
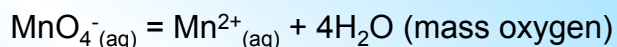
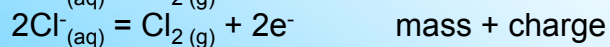
Conventionally always put the oxidised species on the left, the reduced species on the right



1. Separate the reaction into a reduction and oxidation part

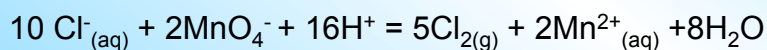


2. Balance each 1/2 reaction with respect to mass then with respect to charge. Use e^- , H^+ , H_2O or OH^-



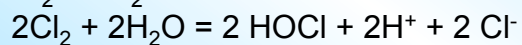
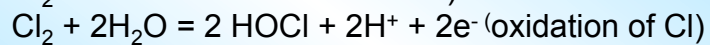
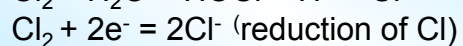
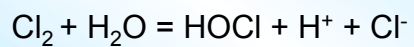
3. Combine half reactions so electron gain equals loss

$$5^*A = 10 e^-; 2^*B = 10 e^- \text{ i.e. } 5^*A + 2^*B$$



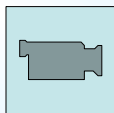
4. Check for atom and charge balance

Example where the same compound is being oxidised and reduced:



This may have been what happened to Cl_2 released from the degassing of the early Earth.

The Periodic table



www.youtube.com/watch?v=zUDDiWtFtEM

Periodic Table of Beer Styles

A brief description of beer styles with commercial examples

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	
1. Belgian wizen 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	2. Lambic 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	3. Belgian gold ale 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	4. Belgian white 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	5. Gueuze 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	6. Tripel 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	7. American wheat 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	8. Faro 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	9. Saison 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	10. Pale ale 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	11. American lite 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	12. Munich helles 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	13. Helles bock 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	
14. Weizenbier 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	15. Fruit beer 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	16. Belgian pale ale 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	17. American pale ale 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	18. Ordinary bitter 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	19. Scottish light 68° 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	20. English mild 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	21. Dry stout 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	22. Foreign extra stout 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	23. German pilsner 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	24. American standard 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	25. Dortmunder 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	26. Doppelbock 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	
27. Dunkelweizen 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	28. Flanders red 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	29. Belgian dark ale 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	30. India pale ale 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	31. Special bitter 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	32. Scottish heavy 70° 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	33. American brown 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	34. Brown porter 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	35. Sweet stout 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	36. Imperial stout 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	37. Bohemian pilsner 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	38. American premium 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	39. Munich dunkel 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	40. Traditional bock 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4
41. Weizenbock 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	42. Oud bruin 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	43. Dubbel 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	44. American amber ale 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	45. Extra special bitter 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	46. Scottish Export 80° 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	47. English brown 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	48. Robust porter 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	49. Oatmeal stout 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	50. Russian imperial stout 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	51. American pilsner 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	52. American dark 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	53. Schwarzbier 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	54. Eisbock 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4
55. Kölsch 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	56. Bière de garde 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	57. Oktoberfest 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	58. Cream ale 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	59. Smoked beer 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	60. English old (strong) ale 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	61. Altbier 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	62. Vienna 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	63. Steam beer 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	64. Barleywine 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4	65. Strong "Scottish" ale 1.004-1.006 1.005-1.010 2.5-3.4 2.1-2.4			

Key

Style number
1.004-1.006
1.005-1.010

Style name
Faro

ABV
Alcohol by volume
4.8-6.5
15-20

IBU
International Bittering Units
15-50

Original gravity
1.044-1.066
1.005-1.015

Final gravity

SRM
Color by standard reference method

Key to yeast type

Style family key

MIXED STYLES

Rejected elements of the periodic table

1 H																	2 Td
Hélium																	Tedum
3 Ac	4 Cx													5 M	6 Ct	7 Fl	8 P
Actium	Clorox													Moron	Carton	Florentine	Pylon
9 Bg	10 Hx	11 A	12 Pk	13 Su	14 V	15 Bs	16 L	17 As	18 Cr								
Belgium	Hydrox	Anodyne	Pekingese	Sumerian	Vinyl	Bosporus	Linoleum	Asinine	Crouton								
19 Dm	20 Am	21 At	22 Ch	23 Ca	24 To	25 Ge	26 An	27 Rp	28 Pr								
Delirium	Aspartame	Antipathy	Chagrin	Canadian	Talc	Geranium	Antigen	Rapine	Princeton								
29 Bz	30 Cn	31 Pz	32 Qt	33 Gu	34 X	35 Sn	36 Vi	37 Cd									
Byzantium	Collagen	Pizzazz	Quotidian	Gummi	Xena	Sin	Vaine	Calliedon									
38 Im	39 Fg	40 Gb	41 Gv	42 Bn	43 Cb	44 Lu											
Imodium	Fahrvorg-nigen	Sanatorium	Asparagus	Hefnerium	Antigone	Grenadine											
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