Example.—Iron ore is to be reduced to pig iron in an electric furnace, and the flux and charcoal on hand for the charge analyze as follows:—

Iron Ore.		Limestone.		Charcoal.	
Fe_2O_3	90	$CaCO_3$	90	Fixed .C....	90
SiO_2	8	$MgCO_3$	3	Volat'e Mt'r.	6
Al_2O_3	2	SiO_2	2	SiO_2	2
				Al_2O_3........	1
				K_2O, Na_2O..	1

Assume the pig iron made will contain 4% of carbon and 3% of silicon; that the slag may be 65% ($SiO_2 + Al_2O_3$); that the gases contain only the CO_2 from the limestone, and none from the reductions.

Required: (1) The weights of ore, limestone, and charcoal to charge per 100 of pig iron made; (2) the percentage composition of the gases; (3) the weight and percentage composition of the slag.

Solution: (1) The weight of ore needed is that necessary to supply the 93 parts (100 — 4 — 3) of iron in the pig iron. This will require 133 parts of Fe_2O_3, which will be contained in 133 ÷ 0.90 = 148 parts of ore.

The weight of charcoal needed is that necessary to furnish enough fixed carbon to reduce the iron oxide and that silica which is reduced, and to supply the carbon in the pig iron. These quantities are:—

Reduction of Fe_2O_3:	93 × 36/112	= 29.9
Reduction of SiO_2:	3 × 24/ 28	= 2.6
For carbon dissolved	.. ..	= 4.0
Total requirement		= 36.5
Charcoal required 36.5/0.90	..	= 40.6

The weight of flux required is best found by calling it x, and then figuring out the slag, as follows:—

Silica in the slag will be that in the ore, flux, and fuel, minus that reduced to silicon. Therefore,

In ore	148 × 0.08 =	11.8
In flux	x × 0.02 =	0.02 x
In fuel	40.6 × 0.02 =	0.8
Reduced	3 × 60/28 =	6.4
Silica in slag	=	6.2 + 0.02 x

By similar calculations we find the slag to contain, as a whole:—

Silica	6.2 +	0.02 x
Alumina	3.4	
Lime		0.50 x
Magnesia		0.04 x
Alkalies	0.4	
Total weight	10.2 +	0.56 x

If the slag is to be 65% of silica and alumina together, then

$$0.65\ (10.0 + 0.56x) = 9.6 + 0.2x$$

from which $x = 9.$

The above solution is perfectly general, and applies to all kinds of ore, flux, and fuel, and the production of any desired kind of slag.

(2) The gases will contain the fixed carbon of the charcoal (except that part that goes into the pig iron) in the state of CO, the carbonic acid driven off the flux, and the volatile matter from the charcoal. The latter may be assumed as composed of equal parts by volume of hydrogen, carbon monoxide, and carbon dioxide, which would correspond to weights of those gases in the proportion of 2:28:44. The gases passing off will therefore be, in parts by weight:

CO from fixed carbon	32.5 × 28/12 = 75.8	
CO from volatile matter.	2.7 × 28/74 = 1.0	76.8
CO_2 from volatile matter	2.7 × 44/74 = 1.6	
CO_2 from flux	9.0 × 0.44 = 4.0	
H_2 from volatile matter....	2.7 × 2/74 = 0.1 —	0.1
Total weight of gases		82.5

Percentage composition of gases by volume:—

			Per cent.
CO	76.8÷126 =	6.10 =	92.4
CO_2	5.6÷1.98 =	2.8 =	4.2
H_2	0.1÷0.09 =	2.2 =	3.4
		6.60	100.0

The volumes 61.0, 2.8, and 2.2 represent cubic meters of these gases per 100 kgs. of pig iron made; if multiplied by 16 they give the cubic feet per 100 lbs. of pig iron.

(3) The slag will contain, substituting x × 9:—

		Per cent.
Silica	6.4 =	42.4
Alumina	3.4 =	22.5
Lime	4.5 =	29.8
Magnesia	0.4 =	2.65
Alkalies	0.4 =	2.65
	15.1	100.00

Combined Blast and Electrical Furnace.—The electrical reduction of iron ore differs radically from blast-furnace practice in one essential particular, viz., that since no air is blown in, any excess of carbon above that consumed in reduction must remain unused, accumulate, and eventually clog the furnace. The amount to be used as a minimum cannot, moreover, be calculated until we know how much Co_2 will be formed in reduction, and that is an unknown quantity unless arrangements are made so that none can be formed. The following modifications of working an electrical pig-iron furnace are possible, with the object in view of avoiding the accumulation of excess carbon in the crucible:—

(1) A deficit of carbon may be put into the charge, thus permitting unreduced iron oxide to escape in the slag, and preventing unused carbon from accumulating. This solution leads to the disadvantages of loss of iron, heavy corrosion of lining of furnace, and heavy consumption of electrode carbon. It may have the secondary result of preventing reduction of silica or taking up of carbon by the iron, and thus furnish a metal with high melting point and approaching steel in composition. Such slag would also remove some of the phosphorous in the charge, but practically no sulphur.

(2) A charge of ore and flux without fuel may be run through the furnace whenever an accumulation of carbon occurs, as is shown by the resistance of the furnace falling off and the furnace getting cold. This was the device adopted in the experiments of the Canadian commission at Sault Ste. Marie, but while permissable in experimental work, it would not do to thus periodically derange a furnace in regular running.

Charge Sheet—per 100 of Pig Iron Produced.

Charges.	Pig Iron.	Slag.	Gases.
Ore: (148.0)			
Fe_2O_3 ..133.2	Fe 93.0		O.......40.2
SiO_2 ... 11.8	Si 3.0	SiO_2.... 5.4	O....... 3.4
Al_2O_3 .. 3.0		Al_2O_3.... 3.0	
Limestone: (9.0)			
CaO ... 4.5		CaO.... 4.5	
MgO ... 0.4		MgO ... 4.5	
SiO_2 ... 0.2		SiO_2.... 0.2	
CO_2 .... 4.0			Co_2..... 4.0
Charcoal: (4.06)	C 4.0		
Fx'd C .. 36.5			C.......32.5
CO 1.0			CO..... 1.0
CO_2 ..... 1.6			CO_2.... 1.6
H_2 ...... 0.1			H_2...... 0.1
SiO_2 .... 0.8		SiO_2.... 0.8	
Al_2O_3 ... 0.4		Al_2O_3 ... 0.4	
$(NaK)_2O$. 0.4		$(NaK)_2O$. 0.4	
Totals 197.9	100.0	15.1	82.8

(3) The fuel may be calculated only for the production of CO in the furnace, and this condition approximated by