UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA *EXTRACTION METALLURGY*
SUBJECT	:	**PYROMETALLURGY III**
CODE	:	**MYP3111**
DATE	:	SUMMER SSA EXAMINATION 2015 7 DECEMBER 2015
DURATION	:	(SESSION 1) 08:00 - 11:00
WEIGHT	:	40:60
TOTAL MARKS	:	100

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NUMBER OF PAGES	:	5 PAGES AND 2 ANNEXURES	

INSTRUCTIONS

1. ANSWER ALL QUESTIONS
2. CALCULATORS ARE PERMITTED

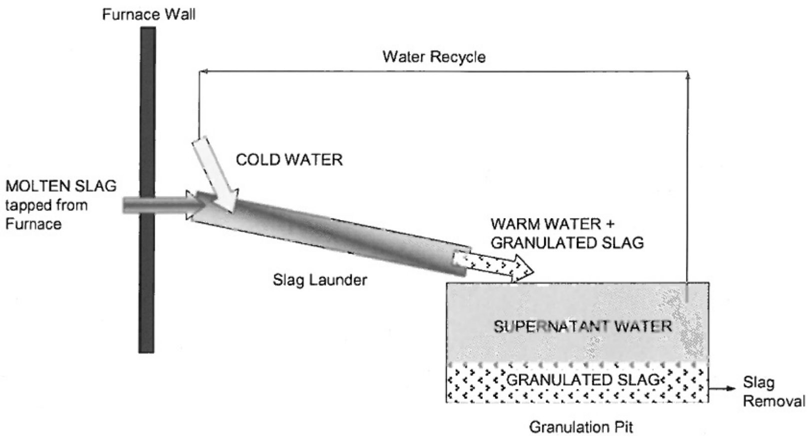
QUESTION 1

You are requested to design a 6-in-line electric furnace for Lonmin. They are prospecting to smelt 600 t of concentrate daily. If the specific smelting energy is 1200 kWh/t and that specific power input 160 kW/m^2 of hearth area, calculate the required hearth area of the furnace?

[14]

QUESTION 2

In order to decrease the heat released in the atmosphere by the products from the furnace, it is suggested that the slag produced be cooled with the use of eater. The estimated temperature of the cold water used is 30°C. The slag molten slag is assumed to be fayalite slag leaving the furnace at 1300°C. If the projected final temperature at both and slag is 45°C, calculate the minimum capacity of the water dam of water that should be stored in order to cool down an amount of 100t of slag daily.



Hint: Granulation means that the slag freezes upon contact with the cold water and becomes a solid, consisting of small particles. The heat that is transferred to the cold water when the slag is cooled is of course the same that it would take to heat up and melt solid slag. Use the mean heat capacities for both slag and water, but do not forget to take the heat of fusion for slag into account; this is given in the table under Ho298 for Fe2SiO4liq.

[18]

QUESTION 3

In hydrometallurgy of cobalt, many impurities are targeted for removal as the pollution of the deposited cobalt has to be avoided. Milk of lime is generally used. It transpires that during impurities removal with the use of milk of lime, being in sulphates solutions, the formation of gypsum (namely $CaSO_4$) is confirmed. In the thickener, the solid mainly composed of gypsum is removed. It is suggested that calcium oxide can be produced from gypsum and sold to Lafarge. If the analysis of the solid collected from the thickener shows that 90% is mainly $CaSO_4$. Lafarge is in need of 50t of CaO daily, calculate:

3.1 The daily mass that must be produced by the hydrometallurgical plant

3.2 The daily mass that must be produced if Phalabora wishes to buy 30t of sulfuric acid

3.3 The monthly cost in 3.1 if you used methane as fuel?

[18]

QUESTION 4

Bricks and castables manufactured from highly refractory (high-melting) materials (such as magnesia and dolomite) are useful for 'basic' applications, for example soda slags. It is said that the concentrates you receive for smelting contain a bit of moisture. During the strategic meeting it is your responsibility to determine the kind of refractories that the company has to order. Your working temperature is 1500°C. One of your colleague suggest dolomite as suitable for your operations. Discuss and make a sound decision. Reactions are needed to support your opinion.

[14]

QUESTION 5

You have shut down the furnace and have refurbished it. It is time to heat up the furnace to reach the required temperature. Two fuels are at your disposal for that purpose namely methane and coke. Normal air is used for combustion. Based on the net calorific value (NCV), decide which suits you best.

[12]

QUESTION 6

You are provided with the table below.

Slag Origin	SiO_2	FeO	CaO	Al_2O_3
Lead blast furnace	29	36	12	4
Copper reverb furnace	35	44	6	4
Thomas raw iron	33	1	50	14

You are producing lead and the analysis of the slag shows that there is no alumina and that more silica is present, thus changing the basicity index. Calculate the amount of CaO that should be added to adhere to the above table? *Assume 1 t of slag is produced*

[12]

QUESTION 7

During the oxygen blowing for copper blister production, it is said that care should be taken of the environment. The Department dealing with the Environmental issues has inspected your plant and expert have analyzed the gas that you are releasing in the atmosphere and found that there is very high pollution. Hefty penalties have been issued to your company due to high SO_2 in the off-gas. The CEO requests that you, as the plant Manager, resolve the issue speedily and has put at your disposal enough finances to attend to the above. We now wish to hear your propects.

[12]

TOTAL MARKS 100

Substance: Name	Formula	State	Mol Mass g/mol	Enthalpy H^o_{298} J/mol	Entropy S^o_{298} J/(mol K)	Temperature Range K	Heat Capacity $C = a + b\,10^{-3}T$ J/(mol K): a	b	Mean
Acetylene	C_2H_2	gas	26.0	226 731	201.0	298 - 3000	50.2	14.2	
Aluminium	Al	sol	27.0		28.3	298 - 933	33.0	-20.7	
	Alliq	liq		10 711	11.5	933 - 2790	31.7		
Aluminium Oxide, *alumina*	Al_2O_3	sol	102.0	-1675 274	50.9	298 - 800	58.2	83.5	
Cadmium	Cd	sol	112.4		51.8	298 - 594	22.3	12.2	
	Cdliq	liq		6 192	10.4	594 - 1038	29.7		
	Cdgas	gas		111 796	167.7	1038 - 2000	20.8		
Cadmium Carbonate	$CdCO_3$	sol	172.4	-751 865	92.5	298 - 600	43.1	131.8	
Cadmium Oxide	CdO	sol	128.4	-258 990	54.8	298 - 1500	42.5	10.1	
Calcium Oxide, *lime*	CaO	sol	56.1	-635 089	38.1	298 - 3200	46.0	6.0	*56.3*
Ca-Carbonate, *calcite*	$CaCO_3$	sol	100.1	-1206 921	92.9	298 - 1200	74.8	50.2	*110.4*
Carbon, *graphite*	C	sol	12.0		5.7	298 - 1100	4.9	17.2	*16.3*
Carbon Monoxide	CO	gas	28.0	-110 541	197.7	298 - 3000	28.7	2.6	*29.7*
Carbon Dioxide	CO_2	gas	44.0	-393 505	213.8	298 - 5000	51.9	3.0	*60.9*
Chromium	Cr	sol	52.0		23.6	298 - 2130	20.3	12.1	*30.0*
	Crliq	liq		16 900	8.0	2130 - 2945	39.3		
Chromium(III) Oxide	Cr_2O_3	sol	152.0	-1139 701	81.2	298 - 2603	114.8	11.2	
Copper	Cu	sol	63.5		33.2	298 - 1358	22.0	7.4	
	Culiq	liq		13 138	9.7	1358 - 2843	32.8		
Copper(I) Oxide, *cuprite*	Cu_2O	sol	143.1	-170 707	92.3	298 - 1517	56.4	25.8	
	Cu2Oliq	liq		64 768	42.7	1517 - 2000	99.9		
Copper(II) Oxide	CuO	sol	79.5	-156 063	42.6	298 - 1397	40.8	13.9	
Chalcopyrite	$CuFeS_2$	sol	183.5	-190 372	125.0	298 - 830	78.6	63.6	
Cu(I)sulfide, *Chalcocite*	Cu_2S	sol	159.1	-81 170	116.2	298 - 1400	47.9	97.2	
	Cu2Sliq	liq		12 845	9.2	1400 - 2000	89.7		
Cu(II)sulfide, *Covellite*	CuS	sol	95.6	-53 095	66.5	298 - 1300	44.4	11.0	
Hydrogen	H_2	gas	2.0		130.7	298 - 5000	28.2	2.7	
Iron	Fe	sol	55.8		27.3	298 - 1809	17.4	25.0	
	Feliq	liq		13 807	7.6	1809 - 3158	40.9	1.7	*45.0*
Iron Oxide, *wüstite*	FeO	sol	71.8	-267 270	57.6	298 - 1650	47.9	10.7	
		liq		24 058	14.6	1650 - 3687	68.2		
Iron Oxide, *magnetite*	Fe_3O_4	sol	231.5	-1118 383	146.1	298 - 1870	75.5	240.1	*205.0*
	Fe3O4liq	liq		138 072	73.8	1870 - 2000	213.4		
Iron Oxide, *hematite*	Fe_2O_3	sol	159.7	-824 248	87.4	298 - 1700	78.1	99.8	
Iron Carbonate, *siderite*	$FeCO_3$	sol	115.9	-740 568	92.9	298 - 800	48.7	112.1	
Iron Sulfide, *pyrrhotite*	FeS	sol	87.9	-105 441	60.8	298 - 598	35.8	49.6	
Iron Sulfide, *pyrite*	FeS_2	sol	120.0	-171 544	52.9	298 - 1000	56.0	27.8	
Lead	Pb	sol	207.2		64.8	298 - 600	24.2	8.7	
	Pbliq	liq		4 770	7.9	600 - 1200	32.5	-3.1	
Lead Oxide, *litharge*	PbO	sol	223.2	-218 062	68.7	298 - 1159	41.8	16.1	
	PbOliq	liq		25 522	22.0	1159 - 2000	65.0		
Lead Sulfide, *galena*	PbS	sol	239.3	-98 634	91.3	298 - 1386	46.6	9.5	
	PbSliq	liq		18 828	13.6	1386 - 2000	66.9		
Lead Sulfate, *anglesite*	$PbSO_4$	sol	303.3	-923 137	149.5	298 - 1139	66.5	110.0	
Magnesium	Mg	sol	24.3		32.7	298 - 922	21.4	11.8	
	Mgliq	liq		8 954	9.7	922 - 1361	32.6		
	Mggas	gas		146 440	148.6	1361 - 2000	20.8		
Mg-Carbonate, *magnesite*	$MgCO_3$	sol	84.3	-1095 798	65.7	298 - 700	47.8	99.0	
Mg-Oxide, *periklase*	MgO	sol	40.3	-601 241	26.9	298 - 3105	42.8	6.0	

THERMODYNAMIC DATA

Substance: Name	Formula	State	Mol Mass g/mol	Enthalpy H^o_{298} J/mol	Entropy S^o_{298} J/(mol K)	Temperature Range K	Heat Capacity $C = a + b\ 10^{-3} T$ J/(mol K) a	b	Mean
Manganese	Mn	sol	54.9		32.0	298 - 1360	20.7	18.7	
Manganese Carbonate	$MnCO_3$	sol	114.9	-894 100	85.8	298 - 700	58.1	85.4	
Manganese Oxide	MnO	sol	70.9	-385 221	59.7	298 - 1500	42.9	10.9	
Mercury (Quicksilver)	Hg	liq	200.6		75.9	298 - 630	28.4	-2.1	
	Hggas	gas		61 291	174.8	630 - 3000	20.8		
Mercury Oxide, red mercury	HgO	sol	216.6	-90 789	70.3	298 - 800	36.6	27.6	
Mercury Sulfide, *cinnabar*	HgS	sol	232.7	-53 346	82.4	298 - 1096	43.8	15.6	
	HgSgas	gas		127 194	254.2	1096 - 2000	36.6	0.5	
Methane	CH_4	gas	16.0	-74 873	186.2	298 - 1000	19.6	54.1	
Nickel	Ni	sol	58.7		29.9	298 - 500	19.1	23.5	
Nickel Carbonyl	$Ni(CO)_4$	gas	170.8	-602 910	410.6	298 - 2000	152.7	29.1	
Nitrogen	N_2	gas	28.0		191.6	298 - 1600	28.0	3.1	*30.8*
Oxygen	O_2	gas	32.0		205.1	298 - 5000	31.9	2.5	*38.3*
Palladium	Pd	sol	106.4		37.8	298 - 1400	24.2	6.4	
Palladium Oxide	PdO	sol	122.4	-115 478	38.9	298 - 1200	21.0	34.7	
Platinum	Pt	sol	195.1		41.6	298 - 2045	24.3	5.4	
	Ptliq	liq		19 665	9.6	2045 - 4096	34.7		
Silicon	Si	sol	28.1		18.8	298 - 1687	22.8	3.9	
	Siliq	liq		50 208	29.8	1687 - 3504	27.2		
Silica	SiO_2	sol	60.1	-910 857	41.5	298 - 1996	29.2	56.8	*65.0*
	SiO2liq	liq		9 565	7.8	1996 - 3000	85.8		
Silver	Ag	sol	107.9		42.7	298 - 1234	24.3	2.5	
	Agliq	liq		11 297	9.2	1234 - 2433	33.5		
Slag, *calcium ortho silicate*	Ca_2SiO_4	sol	172.2	-2315 216	120.8	298 - 1121	145.9	40.8	
	Ca2SiO4liq	liq		71 100	29.6	2403 - 2800	209.2		
Slag, *fayalite*	Fe_2SiO_4	sol	203.8	-1479 902	145.2	298 - 1490	125.5	60.6	
	Fe2SiO4liq	liq		92 174	61.9	1490 - 1700	240.6		
Sulfur	S	sol	32.1		32.1	298 - 368	16.8	20.1	
	Sliq	liq		1 720	4.4	368 - 882	30.0	6.8	
	Sgas	gas		128 599	228.2	882 - 5000	35.2	1.9	
Sulfur Dioxide	SO_2	gas	64.1	-296 813	248.2	50 - 500	30.8	31.9	*39.0*
	SO2hi				0.0	500 - 5000	52.5	3.0	*60.7*
Heat of Fusion	Ice	sol	*5 980*						
Water	H_2O	liq	18.0	-285 830	69.9	298 - 373	59.7	23.0	*75.5*
	H2Ogas	gas		-241 827	188.8	373 - 1600	30.1	10.4	*38.5*
Zinc	Zn	sol	65.4		41.6	298 - 693	22.2	10.5	
	Znliq	liq		7 322	10.6	693 - 1 180	31.4		
	Zngas	gas		130 415	161.0	1 180 - 2 000	20.8		
Zinc Carbonate	$ZnCO_3$	sol	125.4	-812 780	82.4	298 - 500	38.9	138.1	
Zinc Oxide, *zincite*	ZnO	sol	81.4	-350 460	43.6	298 - 2248	41.4	9.5	*53.3*
Zinc Sulfide, *sphalerite*	ZnS	sol	97.4	-201 669	57.7	298 - 1293	44.7	10.6	*52.8*

Temperature	K	=	273 + °C
Universal gas constant	R	=	8.31 J/(mol K)
Mol volume of gases	V_{mol}	=	22.4 L/mol
Oxygen in air	oav	=	21.0% by vol
Power	1 W	=	1 J/s