



<u>PROGRAM</u>	BACHELOR OF TECHNOLOGY <i>EXTRACTION METALLURGY</i>
<u>SUBJECT</u>	NON-FERROUS EXTRACTION METALLURGY
<u>CODE</u>	MNF41-2
<u>DATE</u>	JUNE EXAMINATION 2 June 2016
<u>DURATION</u>	(SESSION 2) 12:30 - 15:30
<u>WEIGHT</u>	40 : 60
<u>TOTAL MARKS</u>	96

<u>ASSESSOR</u>	Ms MAPILANE MADIBA, DR. WILLIE NHETA
<u>MODERATOR</u>	MARCEL KALEMBA
<u>NUMBER OF PAGES</u>	4 PAGES AND A 2-PAGE ANNEXURE

INSTRUCTIONS

- First read carefully through all questions; only then
- Answer all questions in any sequence – but
- Please start answering each question on a new page
- You must clearly demonstrate how you arrived at a given answer, results alone are insufficient
- Finally: Check whether an answer makes sense; is the result likely?
- Calculators are permitted but nothing else because
- All data required for calculations are provided in the Annexure

QUESTION 1

[10]

Discuss validity/invalidity of the following statements :

- 1.1 Indians are known to have produced copper first. (2)
- 1.2 Primary metals refer to the more important metals and secondary metals refer to metals of minor importance. (4)
- 1.3 The voltage requirement for electro-refining of a given metal is generally much less than that needed for its electro-winning. (4)

QUESTION 2

[30]

Copper converting

Copper converter is charged with 20 tons of matte and blown down to blister copper. Copper grade of the matte is 46%. The flux used carries 4% Cu_2S , 16% FeS and 80% SiO_2 . The slag carries 29% SiO_2 . Assume no copper loss in the slag. Also air is supplied at the rate of $90\text{m}^3/\text{min}$.

Calculate:

- (a) Total weight of flux and slag produced (6)
- (b) The cubic meter of the blast for the entire blow (6)
- (c) The blowing time for each of the stages (6)
- (d) Percent SO_2 in the gases (5)
- (e) Heat generated in both stages (7)

QUESTION 3

[12]

Copper electrolysis

In a copper (II) sulphate electrolysis experiment:

Electrode cathodic reaction is : $\text{Cu}^{2+}_{(\text{aq})} + 2\text{e}^- \implies \text{Cu}_{(\text{s})}$ and copper atomic mass is 64g

- (a) How much copper is deposited on the cathode by a 0.2A current flowing for 10 minutes? (6)
- (b) How long must a 0.1 A current be passed to deposit 1g of copper on the cathode? (6)

QUESTION 4

[14]

Zinc

- 4.1 Zinc can be extracted from blende by hydrometallurgical or pyrometallurgical processes. Write and explain the chemical reactions taking place in the extraction of zinc in pyro-metallurgical process. (6)
- 4.2 Electro-winning is one of the most important processes in hydrometallurgy of zinc. Calculate how long it will take for 20 amp current flowing through a solution of zinc sulphate (ZnSO_4) in order to produce 25 g of Zn metal. (8)

QUESTION 5

[12]

Platinum

State and explain the characteristics of the 3 platinum reefs mined in South Africa.

QUESTION 6

[8]

Gold

Discuss why gold has found a big use in jewellery industry.

QUESTION 7

[10]

Uranium

With the aid of chemical reactions, explain why manganese dioxide is used in leaching process of uranium ores.

TOTAL = 96

Data you need for calculations:

Faraday constant 26.8 Ah/mol

Standard reduction potentials:

Oxygen in air:

MNF41-2 NON-FERROUS EXTRACTION METALLURGY

$\text{Cu}^{2+} + 2\text{e} = \text{Cu}$	$E^{\circ} = 0.34 \text{ V}$	by volume	21.0%
$\text{Zn}^{2+} + 2\text{e} = \text{Zn}$	$E^{\circ} = -0.76 \text{ V}$	by mass	23.2%

**Good
Luck**

MNF41-2 NON-FERROUS EXTRACTION METALLURGY

Substance				Enthalpy	Entropy	Heat Capacity				
Name	Formula	State	Mol Mass g/mol	H ₂₉₈ ^o J/mol	S ₂₉₈ ^o J/(mol K)	Temp Range K	a	b	C _{mean} x 10 ³ J/(mol K)	
Acetylene	C ₂ H ₂	gas	26.0	226 731	201.0	298 - 3000	50.2	14.2	72.9	
Aluminium	Al	sol	27.0		28.3	298 - 933	19.8	14.4	28.5	
	Alliq	liq		10 711	39.8	933 - 2790			31.7	
Aluminium oxide, <i>alumina</i>	Al ₂ O ₃	sol	102.0	-1 675 274	50.9	298 - 800	58.2	83.5	101	
	Al ₂ O ₃ hi					800 - 2327	112.2	12.7	133	
Cadmium	Cd	sol	112.4		51.8	298 - 594	22.3	12.2	27.4	
	Cdliq	liq		6 192	62.2	594 - 1040			29.7	
	Cdgas	gas		111 796	167.7	1040 - 1500			20.8	
Cadmium carbonate	CdCO ₃	sol	172.4	- 751 865	92.5	298 - 600	43.1	131.8	99.9	
Cadmium oxide	CdO	sol	128.4	- 258 990	54.8	298 - 1500	43.0	9.7	51.5	
Calcium oxide, <i>lime</i>	CaO	sol	56.1	- 635 089	38.1	298 - 3200	46.0	6.0	56.0	
Ca-carbonate, <i>calcite</i>	CaCO ₃	sol	100.1	-1 206 921	92.9	298 - 1200	74.8	50.2	110	
Carbon, <i>graphite</i>	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 - 5000	30.9	1.9	33.0	
Carbon dioxide	CO ₂	gas	44.0	- 393 505	213.8	298 - 500	26.0	37.2	35.6	
	CO ₂ hi					500 - 5000	51.9	3.0	60.1	
Chromium	Cr	sol	52.0		23.6	298 - 2130	20.3	12.1	30.0	
	Crliq	liq		16 900	31.6	2130 - 2945			39.3	
Chromium(III)-oxide	Cr ₂ O ₃	sol	152.0	-1 139 701	81.2	298 - 2603	114.8	11.2	131	
Iron-chrome spinel <i>chromite</i>	FeCr ₂ O ₄	sol	223.8	-1 458 124	142.0	298 - 2123	140.1	35.5	183	
Copper	Cu	sol	63.5		33.2	298 - 1358	22.0	7.4	28.0	
	Culiq	liq		13 138	42.8	1358 - 2843			32.8	
Copper(I)-oxide, <i>cuprite</i>	Cu ₂ O	sol	143.1	- 170 707	92.3	298 - 1508	56.4	25.8	79.7	
	Cu ₂ Oliq	liq		- 105 939	135.0	1508 - 2000			99.9	
Copper(II)-oxide, <i>tenorite</i>	CuO	sol	79.5	- 156 063	42.6	298 - 1397	40.8	13.9	48.6	
<i>Chalcopyrite</i>	CuFeS ₂	sol	183.5	- 190 372	125.0	298 - 830	78.6	63.6	114	
Cu(I)-sulfide, <i>chalcocite</i>	Cu ₂ S	sol	159.1	- 81 170	116.2	298 - 1400	47.9	97.2	85.7	
Cu-Matte	Cu ₂ Sliq	liq		- 68 325	125.3	1400 - 2000			89.7	
Cu(II)-sulfide, <i>covellite</i>	CuS	sol	95.6	- 53 095	66.5	298 - 1300	44.4	11.0	53.0	
Gold	Au	sol	197.0		47.5	298 - 1336	24.0	4.4	26.7	
	Auliq	liq		12 552	56.9	1336 - 3130			31.0	
Hydrogen	H ₂	gas	2.0		130.7	298 - 5000	28.2	2.7	35.0	
Iron	Fe	sol	55.8		27.3	298 - 1811	23.1	16.0	38.7	
	Feliq	liq		13 807	34.9	1811 - 3158			45.0	
Iron(II)-oxide, <i>wüstite</i>	FeO	sol	71.8	- 267 270	57.6	298 - 1650	47.9	10.7	58.0	
		liq		- 243 212	72.2	1650 - 3687			68.2	
Iron(II)(III)-oxide, <i>magnetite</i>	Fe ₃ O ₄	sol	231.5	-1 118 383	146.1	298 - 1870	75.5	240.1	207	
Iron-iron spinel Fe [Fe ₂ O ₄]	Fe ₃ O ₄ liq	liq		- 980 311	220.0	1870 - 2000			213	
Iron(III)-oxide, <i>hematite</i>	Fe ₂ O ₃	sol	159.7	- 824 248	87.4	298 - 1700	78.1	99.8	142.0	
Iron carbonate, <i>siderite</i>	FeCO ₃	sol	115.9	- 740 568	92.9	298 - 800	48.7	112.1	106.0	
Iron sulfide, <i>pyrrhotite</i>	FeS	sol	87.9	- 105 441	60.8	298 - 1465	31.0	63.0	68.0	
	FeSliq	liq		- 72 977	82.3	1465 - 3000			62.6	
Iron sulfide, <i>pyrite</i>	FeS ₂	sol	120.0	- 171 544	52.9	298 - 1000	56.0	27.8	73.0	
Lead	Pb	sol	207.2		64.8	298 - 600	24.2	8.7	28.1	
	Pbliq	liq		4 770	72.7	600 - 1200			29.7	
Lead oxide, <i>litharge</i>	PbO	sol	223.2	- 218 062	68.7	298 - 1159	41.8	16.1	53.1	
	PbOliq	liq		- 192 540	90.7	1159 - 2000			65.0	
Lead dioxide, <i>plattnerite</i>	PbO ₂	sol	239.2	- 274 470	71.8	298 - 1200	58.9	20.4	73.4	
Lead sulfide, <i>galena</i>	PbS	sol	239.3	- 98 634	91.3	298 - 1386	46.6	9.5	54.0	
	PbSliq	liq		- 79 806	104.9	1386 - 2000			66.9	
Lead sulfate, <i>anglesite</i>	PbSO ₄	sol	303.3	- 923 137	149.5	298 - 1139	66.5	110.0	144.0	
Magnesium	Mg	sol	24.3		32.7	298 - 922	21.4	11.8	28.5	
	Mgliq	liq		8 954	42.4	922 - 1361			32.6	
	Mggas	gas		146 440	148.6	1361 - 2000			20.8	
Mg-carbonate, <i>magnesite</i>	MgCO ₃	sol	84.3	-1 095 798	65.7	298 - 700	47.8	99.0	94.0	

MNF41-2 NON-FERROUS EXTRACTION METALLURGY

Substance				Enthalpy	Entropy	Heat Capacity			
Name	Formula	State	Mol Mass g/mol	H ^o ₂₉₈ J/mol	S ^o ₂₉₈ J/(mol K)	Temp Range K	a	b	C _{mean} x 10 ³ J/(mol K)
Mg-oxide, <i>periklase</i>	MgO	sol	40.3	- 601 241	26.9	298 - 3105	42.8	6.0	53.0
Manganese	Mn	sol	54.9		32.0	298 - 1517	20.7	18.7	28.6
	Mnliq	liq		12 100	40.0	1517 - 2332			46.0
Manganese carbonate	MnCO ₃	sol	114.9	- 894 100	85.8	298 - 700	58.1	85.4	106
Manganese oxide	MnO	sol	70.9	- 385 221	59.7	298 - 1500	42.9	10.9	52.3
Mn-dioxide, <i>pyrolusite</i>	MnO ₂	sol	86.9	- 520 029	53.0	298 - 523	35.1	66.0	62.9
Mercury (quicksilver)	Hg	liq	200.6		75.9	298 - 630	28.4	-2.1	27.4
	Hggas	gas		61 291	174.8	630 - 3000			20.8
Mercury oxide, <i>red mercury</i>	HgO	sol	216.6	- 90 789	70.3	298 - 800	36.6	27.6	50.8
Mercury sulfide, <i>cinnabar</i>	HgS	sol	232.7	- 53 346	82.4	298 - 1098	43.9	15.4	53.5
	HgSgas	gas		127 194	254.2	1098 - 2000	36.6	0.5	37.1
Methane	CH ₄	gas	16.0	- 74 873	186.2	298 - 1000	19.3	54.8	54.3
Nickel	Ni	sol	58.7		29.9	298 - 1728	19.1	23.5	33.0
	Niliq	liq		17 472	40.0	1728 - 3187			43.1
Nickel carbonate	NiCO ₃	sol	118.7	- 694 544	86.2	298 - 700	67.1	68.1	99.0
Nickel carbonyl	Ni(CO) ₄	gas	170.8	- 602 910	410.6	298 - 2000	152.7	29.1	184.8
Nickel oxide	NiO	sol	74.7	- 239 701	38.0	298 - 2228	20.9	36.5	58.0
Nickel sulfide, <i>millerite</i>	NiS	sol	90.8	- 87 864	53.0	298 - 1249	36.5	27.4	51.0
Ni-sulfide, <i>heazlewoodite</i>	Ni ₃ S ₂	sol	208.1	- 216 313	133.9	298 - 1062			150
Nitrogen	N ₂	gas	28.0		191.6	298 - 1600	28.0	3.1	30.8
Octane (n-octane)	C ₈ H ₁₈	liq	114.2	- 250 000	360.0	298 - 400			254.0
Oxygen	O ₂	gas	32.0		205.1	298 - 5000	31.9	2.5	38.3
Palladium	Pd	sol	106.4		37.8	298 - 1825	24.2	6.4	29.4
Palladium oxide	PdO	sol	122.4	- 115 478	38.9	298 - 1200	21.0	34.7	45.6
Platinum	Pt	sol	195.1		41.6	298 - 2045	24.3	5.4	30.4
	Ptliq	liq		19 665	51.3	2045 - 4096			34.7
Silicon	Si	sol	28.1		18.8	298 - 1685	19.7	6.1	25.5
	Siliq	liq		50 208	48.6	1685 - 3504			27.2
Silica	SiO ₂	sol	60.1	- 910 857	41.5	298 - 1996	29.2	56.8	65.0
	SiO2liq	liq		- 901 292	49.3	1996 - 3000			85.8
Silver	Ag	sol	107.9		42.7	298 - 1234	24.3	2.5	28.0
	Agliq	liq		11 297	51.8	1234 - 2433			33.5
Silver oxide	Ag ₂ O	sol	231.7	- 31 049	121.3	298 - 500	49.2	56.2	70.2
Slag, <i>calcium ortho silicate</i>	Ca ₂ SiO ₄	sol	172.2	-2 315 216	120.8	298 - 2403	145.9	40.8	164
	Ca2SiO4liq	liq		-2 244 000	170.8	2403 - 2800			209
Slag, <i>fayalite</i>	Fe ₂ SiO ₄	sol	203.8	-1 479 902	145.2	298 - 1490	125.5	60.6	153
	Fe2SiO4liq	liq		-1 387 728	61.9	1490 - 1700			241
Sulfur	S	sol	32.1		32.1	298 - 388	16.8	20.1	23.0
	Sliq	liq		2 122	37.6	388 - 882	30.0	6.8	34.1
	S2gas	gas		128 599	228.2	882 - 5000	35.2	1.9	40.2
Sulfur dioxide	SO ₂	gas	64.1	- 296 813	248.2	50 - 500	30.8	31.9	39.0
	SO2hi	hi				500 - 5000	52.5	3.0	60.7
Tin <i>grey</i> <i>white</i>	Sngr	sol		- 2 092	44.1	298 - 398	25.8		25.8
	Sn	sol	150.7		51.2	298 - 505	21.6	18.1	28.8
	Snliq	liq		7 029	65.1	505 - 800			25.5
Tin dioxide, <i>cassiterite</i>	SnO ₂	sol	150.7	- 577 631	49.0	298 - 1903	58.7	18.2	78.8
Water	Ice	sol		-279 850		< 273			37.0
	H ₂ O	liq	18.0	- 285 830	69.9	298 - 373	73.0	7.9	75.5
	H2Ogas	gas		- 241 827	188.8	373 - 1600	30.1	10.0	38.5
Zinc	Zn	sol	65.4		41.6	298 - 693	22.2	10.5	27.1
	Znliq	liq		7 322	52.2	693 - 1 180			31.4
	Zngas	gas		130 415	161.0	1 180 - 2 000			20.8
Zinc carbonate, <i>smithonite</i>	ZnCO ₃	sol	125.4	- 812 780	82.4	298 - 500	38.9	138.1	93.0
Zinc oxide, <i>zincite</i>	ZnO	sol	81.4	- 350 460	43.6	298 - 2248	41.4	9.5	53.3
Zinc sulfide, <i>sphalerite</i>	ZnS	sol	97.4	- 201 669	57.7	298 - 1293	44.7	10.6	52.8

