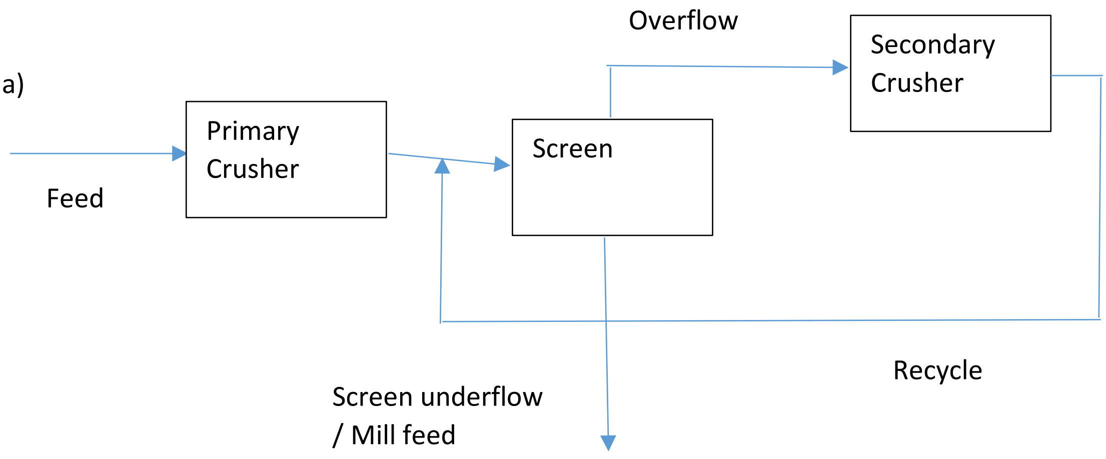
1 a)



b)

	Feed	Crusher product	Recycle	Screen Feed	Overflow	Underflow	Crusher Product
+1 cm	900	540	X	540+X	(540+X)*0.8	(540+X)*0.2	(540+X)*0.8*0.5
-1 cm	100	460	Y	460+Y	(460+Y)*0.25	(460+Y)*0.75	(460+Y)*0.25+ (540+X)*0.8*0.5

As the crusher product is the recycle:

X = (540+X)*0.8*0.5

Y = (460+Y)*0.25 + (540+X)*0.8*0.5

X = 540*0.8*0.5/(1-0.8*0.5) = 360 t/hr

Y = (460+Y)*0.25+360 = 475 / 0.75 = 633.33 t/hr

	Feed	Crusher product	Recycle	Screen Feed	Overflow	Underflow
+1 cm	900	540	360	900	720	180
-1 cm	100	460	633.33	1093.33	273.3333	820

Percentage passing 1 cm in mill feed (screen underflow) is 82%

c) Total volumetric rate of solids is 1000/SGsolid = 357.14 m^3/hr

Total volumetric rate = 357.14/0.35 = 1020.4 m^3/hr

Therefore total water rate = 1020.4 * (1-0.35) = 663.26 m^3/hr

d) As apertures get larger so will the cut size. The circulating load in the crushing circuit will decrease as a greater fraction of the material passed on the screen will leave the circuit in the underflow.

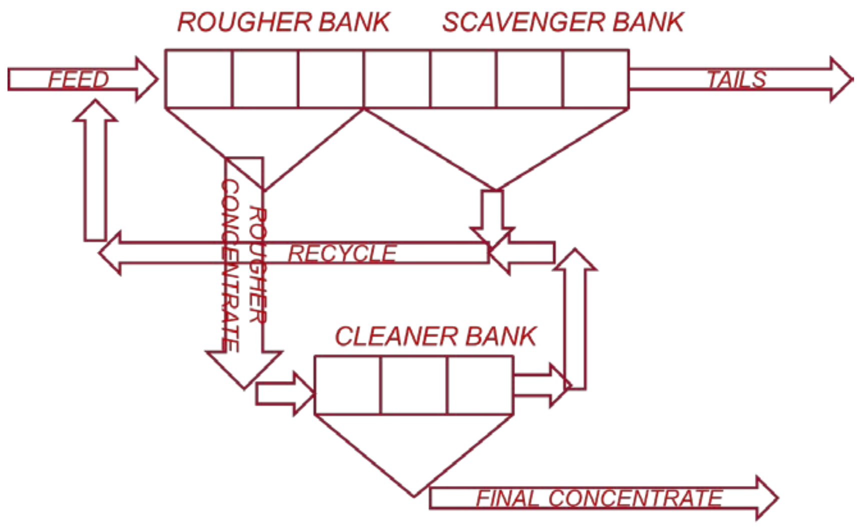
e) P = 1000 * 10 *(sqrt(100/120)-sqrt(100/9000)) = 8074 kW

2 a)

Feed rate	1500	Feed Copper	15
Feed grade	1		

	Cell 1	Cell 2	Cell 3	Cell 4
Concentrate Grade	25	20	15	12
Solids flow rate	10	8	6	5
Concentrate Copper Rate	2.5	1.6	0.9	0.6
Cumulative total	10	18	24	29
Cumulative copper	2.5	4.1	5	5.6
Cumulative Grade	25	22.78	20.83	19.31
Cumulative Recovery	16.66	27.33	33.33	37.33

b)



c) Grade will decrease and recovery increase.

d) Concentrate mass rate from rougher will increase and grade will decrease. The cleaner grade and recovery will decrease. Circulating load will go up. Overall circuit recovery will increase, but grade will decrease.

e) *M* is mass rate of solid is t/hr. *Q* is volumetric rate of water.

1200 = M/SGsolid +Q

(M + Q) / 1200 = SGslurry

Combine to eliminate Q:

(1200 + M * (1-1/SGsolid) = SGslurry * 1200

Solve for M:

M = 1200 *(SGslurry-1)/(1-1/SGsolid)

Given SGslurry = 1.6 and SG solid = 2.6

M = 1170 t/hr

f)

	Nickel Grade
Feed	1.0
Concentrate	10.0
Pulp Zone	0.6

Well mixed means pulp and tailings grade are the same.

Mass flow rates of Feed, Concentrate and Tails (F, C, T)

Overall Mass Balance:

F = C + T

Nickel Mass Balance

0.01 F = 0.1 C + 0.006 T

F is known. Combine equations to eliminate T:

0.01 F = 0.1 C + 0.006 (F – C)

C = F * (0.01 – 0.006) / (0.1 – 0.006)

Concentrate Flow Rate = 49.70 t/hr

Recovery = C *0.1 / (F * 0.01)

Recovery = 42.55 %

Question 3

a)

	Feed	Underflow Cyclone 1	Cyclone 2
150	0	0	0
105	35	84	62
74	58	70	69
53	61	36	45
0	46	10	24

Sum of masses				Cumulative Size Distribution		
Feed	Cyclone 1	Cyclone 2	Size	Feed	Cyclone 1	Cyclone 2
200	200	200	150	1	1	1
165	116	138	105	0.825	0.58	0.69
107	46	69	74	0.535	0.23	0.345
46	10	24	53	0.23	0.05	0.12
0	0	0	0	0	0	0

b)

	Mass Flows			Partition Numbers	
Representative Size	Feed	Cyclone 1	Cyclone 2	Cyclone 1	Cyclone 2
125.5	3.5	3.36	2.48	0.96	0.708571
88.1	5.8	2.8	2.76	0.482759	0.475862
62.6	6.1	1.44	1.8	0.236066	0.295082
26.5	4.6	0.4	0.96	0.086957	0.208696

c) Cyclone one is the preferred cyclone as the partition curve is sharper (steeper) and it has a smaller bypass ratio.

d) The bypass ratio and the water recovery are closely linked. The bypass ratio of the 2nd cyclone is higher than that of the first and therefore it probably has the highest water recovery.

e)

	Mass Rate in overflow Cyclone 1	Cyclone 2
125.5	0.14	1.02
88.1	3	3.04
62.6	4.66	4.3
26.5	4.2	3.64

	Sum of Mass Rates			Cumulative Size Distribution	
	Cyclone 1	Cyclone 2		Cyclone 1	Cyclone 2
150	12	12		1	1
105	11.86	10.98		0.988333	0.915
74	8.86	7.94		0.738333	0.661667
53	4.2	3.64		0.35	0.303333
0	0	0		0	0

Question 4

a) Heap leaching preferred for oxide material as their flotation response is typically quite bad, but have good leach response.
Preferred option for low grade material as it eliminates the need for milling – most costs associated with electro winning.

b) Base metal mines often have a weather oxide region that can be leached with the main sulphide portion of the ore body being milled and floated. Low grade regions that would have been deemed waste could also be leached. If there is a smelter and acid plant on sight, it can generate acid for the leaching.

c) Consider a full leach cycle – 14 months = 365*14/12 days = 425.83 days

Total mass of ore in one cycle = 425.83*60 000 = 25 550 000 tons

Volume of ore = 25 550 000 / 2.4 =10 645 833 m^3

Volume of heap = 10 645 833 / (1-0.2) = 13 307 291 m^3

Area of heap = 13 307 291 * 1.15 / 15 = 10 200 000 m^2 = 1.02 km^2

d) Basis of 1 hr:

Ore into heap = 60000/24 = 2500 t/hr

Cu into heap = 2500 * 0.007 = 17.5 t/hr

Cu out of heap = 8000 * (1.8-0.2) = 12.8 t/hr

Recovery = 12.8/17.5 = 73%

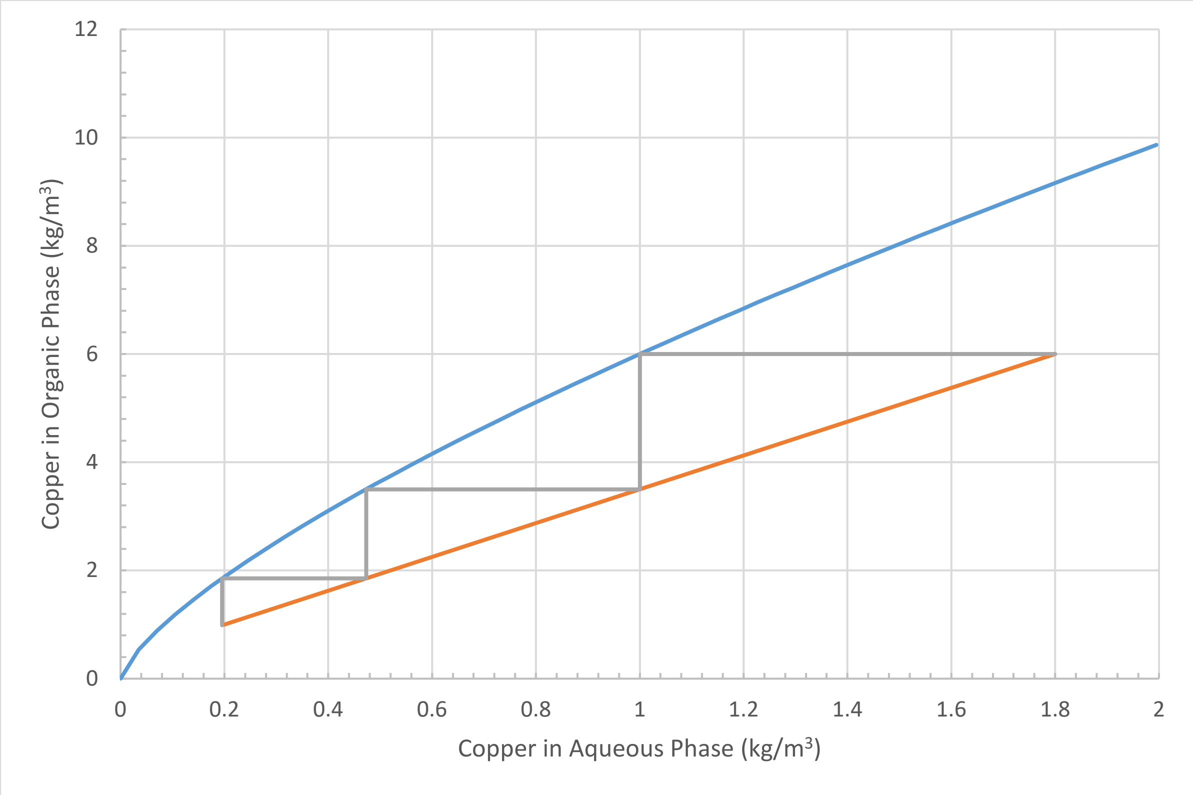
e) Copper out of heap = copper into organic phase

If Q is the volumetric organic rate

12.8 = Q * (6-1)/1000

Q = 2560 m^3/hr

f)



3 stages required

g) Total copper extracted = 12.8 t/hr

60% recovered and copper concentration exiting of 30 kg/m^3 means that it enters at 30/0.6 = 50 kg/m^3

If Q is the volumetric electrolyte rate

Q * (50-30)/1000 = 12.8

Q = 640 m^3/hr