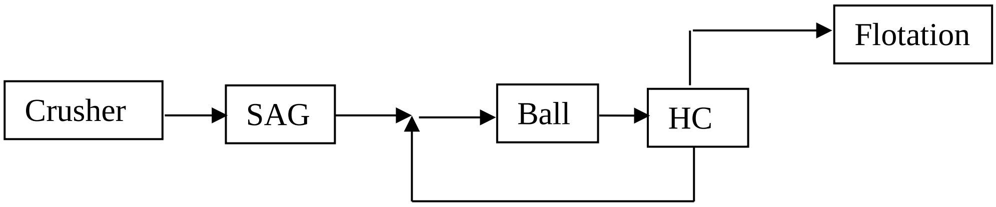
Question 1

a) Draw the circuit, labelling items.



b)

	Feed	SAG Mill product	Recycle	Ball Mill Feed	Ball Mill Product
-75	375	937.5	X	X+1020	X+1020+(Y+480)*0.6
+75	1125	562.5	Y	Y+480	(Y+480)*(1-0.6)
X=(X+625+(Y+375)*0.5)*0.25					
Y=(Y+250)*(1-0.5)*0.8		Y=375*(1-0.5)*0.8/(1-(1-0.5)*0.8)		X=(625+(Y+375)*0.5)*0.25/(1-0.25)	

Solving for the recycle gives the following overall balance:

	Feed	SAG Mill product	Recycle	Ball Mill Feed	Ball Mill Product	Flotation feed
-75	375	937.5	462.5	1400	1850	1387.5
+75	1125	562.5	337.5	900	450	112.5
Total	1500	1500	800	2300	2300	1500

Feed rate to each mill: 1150 tph
Percentage passing 75 microns in product: 1387.5/1500 = 92.5%

c) $\boldsymbol{E = W_i\left(\sqrt{\frac{100}{P_{80}}} - \sqrt{\frac{100}{F_{80}}}\right)}$

E = 17.86 kWh/ton

Power =26.7 MW

d) 30% by volume

Need to find by mass
mass fraction = mass solid/mass slurry

Basis 1 m^3 slurry

Mass fraction = 0.3 * SG solid/(0.3*SG solid + 0.7*SG water)
Mass fraction = 0.517

Mass rate water = 1500 *(1-0.517)/ /0.517
= 1400 tph

e) Solids content in the ball mill feed will be higher than that in the SAG mill feed. This is because the hydrocyclone acts as a water separator as well as a particle size classifier. The underflow will have a higher solids content than the overflow and so the recycle stream will have a higher solids content than the product from the SAG mill, thus increasing the solids content in the ball mill feed.

f) The d50 will become finer.

g) With a finer d50 more material will be classified to the cyclone underflow. This will increase the amount of material being recycled, which will increase the feed rate to ball mill.

Question 2:

a) Start by doing a mass balance down the bank:

	Cell 1		Cell 2		Cell 3		Cell 4	
	Tails	Conc	Tails	Conc	Tails	Conc	Tails	Conc
Cu	13	7	9.1	3.9	6.825	2.275	5.46	1.37
Total	976.7	23.3	961.1	15.6	948.4	12.6	934.8	13.7

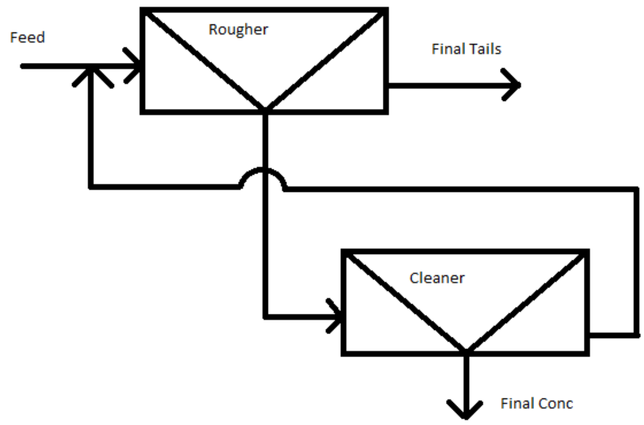
Use this data to calculation the cumulative grade and recoveries:

	Cell 1	Cell 2	Cell 3	Cell 4
Grade	30	28.0	25.5	22.3
Recovery	35	54.5	65.9	72.7

b) Increasing the froth depth will increase the grade and decrease the recovery.

c) In the cleaner bank you target grade because the product is the final concentrate and any lost recovery is recycled back to the rougher. In the scavenger you target recovery as the material is being recycled back to the feed and thus the grade that it is being mixed with is not high. The rougher should have a balanced approach.

d)



e) If X is the recycle from the cleaners and F is the circuit feed:

Rougher Feed = F+X
Rougher Conc = (F+X)*Rrougher
Rougher (and final) tails = (F+X)*(1-Rrougher)
Cleaner Conc = (F+X)*Rrougher*Rcleaner
Cleaner Tails = (F+X)*Rrougher*(1-Rcleaner) = X

Rearrange:

X= F*(Rrougher*(1-Rcleaner))/(1-Rrougher*(1-Rcleaner))

For valuable:

F = 50
X = 28.125
Final Conc = 42.1875

Recovery = Final Conc/F = 84.4%

f)

For gangue:

F=950
X=93.95
Final Conc=10.4

Grade = Valuable Conc/(Valuable Conc+Gangue Conc)
Grade = 80.2% valuable mineral

Question 3

a)
Mass Recovery = Underflow / (Underflow+Overflow)
Mass Recovery = 24 / (24+35) = 40.7%

b) Add all masses starting from smallest size and divide by total mass

	Cummulative Underflow	Overflow
212	1	1
150	0.644	0.962
105	0.403	0.877
74	0.269	0.692
53	0.154	0.431

c) Representative size is the geometric mean. The partition number is calculated by dividing the flow rate in a particular size fraction in the underflow (coarse stream) by that in the feed.

Representative size	P
178	0.86
125	0.66
88	0.33
63	0.23
27	0.20

d) The d50 is approximately 100 microns and the bypass ratio is about 20%.

e) Add the flow rate of the underflow and overflow for each size fraction together. Sum these from the smallest size, diving each sum by the total flow of the feed to produce the cumulative size distribution.

	Cummulative Feed
212	1.00
150	0.83
105	0.68
74	0.52
53	0.32

f) slurry SG = 1 /(mass frac solids/SG solids + (1-mass frac solids)/SG water)

Therefore mass frac solids = (1-1/SG)/(1-1/SGs) (since SG water = 1)

		mass fraction solids
SG feed	1.8	0.741
SG underflow	2	0.833
SG overflow	1.6	0.625

g) Flow rate of underflow is 35 tph. Assume flow rate of feed is F and Overflow is O.

Balance for water:

$F * (1-0.741) = 35 * (1-0.833) + O * (1-0.625)$

Balance for solids:

$F * 0.741 = 35 * 0.833 + O * 0.625$

Solve for F and O:

F = 63 tph
O = 28 tph

Question 4

a) Volume = Mass Ore/SG solid/(1-voidage)

Volume = 500000m^3

b) Volumetric Flow Rate = 10/1000*(1-0.05)*Area = 300

Area = 31579 m^2

Height = Volume/Area = 15.8 m

c) Mass gold in lift = Mass lift * grade = 1500kg

Mass gold in solution = Flowrate * time * concentration = 300 * 24 *150 * 1   g
Mass gold in solution = 1080kg

Recovery = 1080/1500 = 72%

d) X=Xf*(1-(1/(1+kt))^N)

We know the extraction when N = 5 (X1=0.8), we know Xf (=0.95). If we expand to N=10 we can calculate X2 by realising that kt (and thus 1/(1+kt) remains constant). We can write X2 as a function of X1:

X1=Xf*(1-C^N)
X2=Xf*(1-C^(2*N))

Combine and eliminate C:

X2=Xf*(1-(1-X1/Xf)^2)

Therefore X2=92.6 %

e) Volumetric Flowrate = Mass Flow Rate Solids/SGsolids+Mass Flow Rate Water/SGwater

Volumetric Flowrate = 500/2.6+500 = 692 m^3/hr

Residence Time = Total Volume / Volumetric Flowrate = 2000*5/692 = 14.4 hrs

f) Mass rate loaded gold= Mass rate solids*grade*recovery*extraction

Mass rate loaded gold = 500*10*0.8*0.975 = 3900 g/hr

Mass rate carbon = Mass Rate gold /(change in loaded grade)
Mass rate carbon = 3900/(50-10) = 97.5 tph

g)

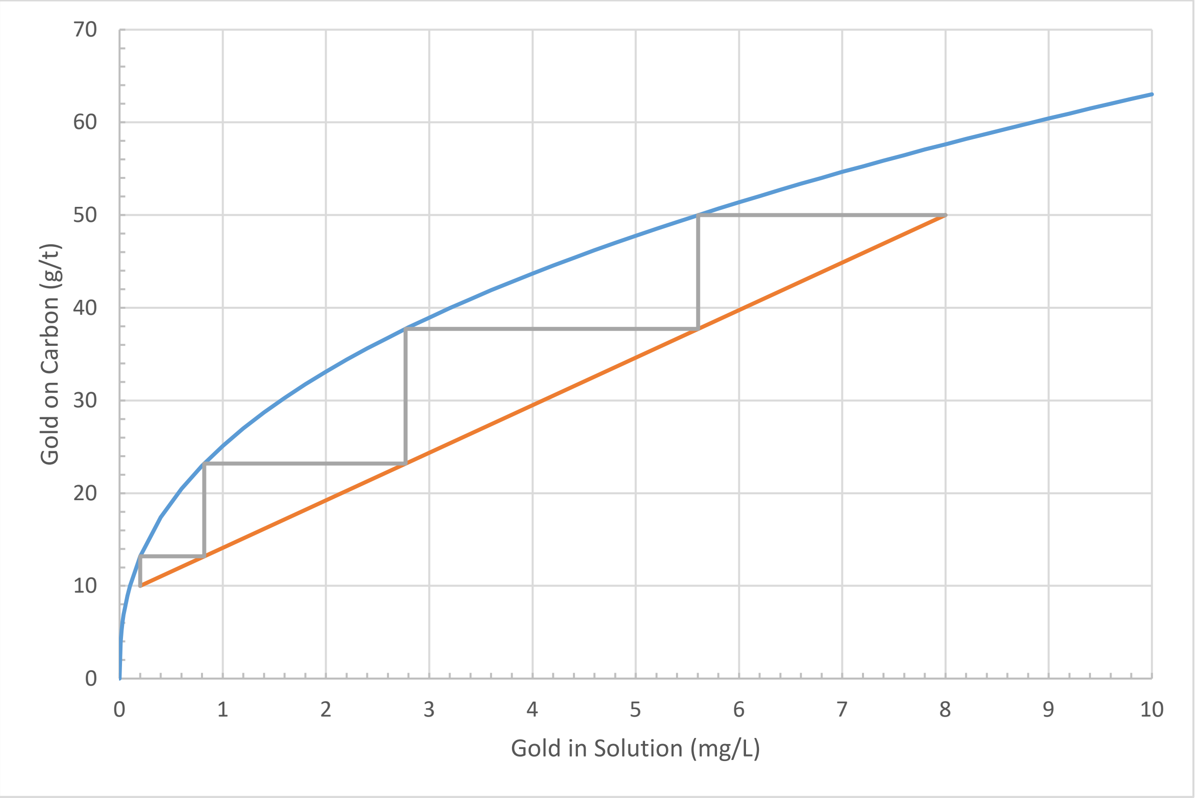
Feed concentration gold = Gold into CIP in solution / Solution rate

Feed concentration gold = 4000 / 500 = 8 mg/l

Exiting concentration gold = Feed Concentration * (1-Recovery) = 8 * (1-0.975) = 0.2 mg/l

8 mg/l in solution and 40 g/t is one end point of operating line.

Other end of operating line is 0.2 mg/l and 10 g/t



Four equilibrium stages are required.