UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA CHEMICAL ENGINEERING
SUBJECT	:	**CHEMICAL PLANT III A**
CODE	:	**ACPA 321**
DATE	:	FINAL EXAMINATION 2014 18 JUNE 2014
VENUE	:	DFC JOHN ORR BUILIDING 2120
DURATION	:	(SESSION 1) 08:30 - 11:30
WEIGHT	:	40: 60
TOTAL MARKS	:	100
FULL MARKS	:	100

EXAMINER	Mr ISHMAEL RAMATSA
MODERATOR	Dr. HILARY RUTTO
NUMBER OF PAGES	5 PAGES (INCLUDING THIS COVER PAGE)

INSTRUCTIONS
- NON- PROGRAMMABLE CALCULATORS PERMITTED.
- ANSWER ALL THE QUESTIONS.

QUESTION 1: CORROSION [20]

1.1. Define corrosion [2]

1.2. Corrosion of metals can be considered as the reverse process of extractive metallurgy.

i. State why corrosion of metal could be considered as a reverse process of extractive metallurgy. Use "rusting of iron" and "steel-making process" as examples. [6]

ii. Illustrate with a figure. [6]

iii. Give the balanced chemical equations of steel rusting and that of making steel from iron oxide. [6]

QUESTION 2: STRUCTURE OF MATERIALS [20]

2.1 Rhodium has an atomic radius of 0.1345 nm (1.345 A) and the density of 12.41g.cm-3. Determine whether it has a BCC or FCC crystal structure. [12]

Rh (Mw= 102,91g/mol).

The Avogadro constant expresses the number of elementary entities per mole of substance and it has the value 6.02214129×10^{23} mol^{-1}.

2.2 Show for the body-centered cubic crystal structure that the unit cell edge length [a] and the atomic radius [R] are related through a =4R/ 3. [8]

QUESTION 3: STRENGTH OF MATERIALS [20]

QUESTION 3

3.1 A pipe has an outside diameter of 25 mm, an inside diameter of 15 mm and length 0.40 m and it supports a compressive load of 40 kN. The pipe shortens by 0.5 mm when the load is applied. Determine

3.1.1 The compressive stress, [5]

3.1.2 The compressive strain in the pipe when supporting this load. [3]

3.2 A bar of thickness 15 mm and having a rectangular cross-section carries a load of 120 kN. **Determine** the minimum width of the bar to limit the maximum stress to 200 MPa. The bar, which is 1.0 m long, extends by 2.5 mm when carrying a load of 120 kN. **Determine** the modulus of elasticity of the material of the bar. [12]

QUESTION 4: THEORETICAL - ENERGY REQUIRED FOR CRUSHING [10]

A material is crushed in a Blake jaw crusher such that the average size of particle is reduced from 50 mm to 10 mm with the consumption of energy of 13.0 kW/ (kg/s). What would be the consumption of energy needed to crush the same material of average size 75 mm to an average size of 25 mm?

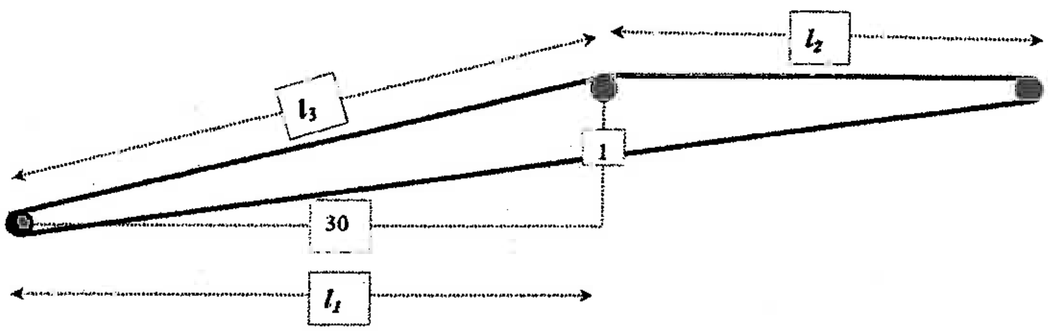
a) Assuming Rittinger's law applies;
   i. Calculate the product of the constants $K_R \cdot f_c$ [2]
   ii. What would be the consumption of energy needed to crush the same material of average size 75 mm to an average size of 25 mm? [2]
b) Assuming Kick's law applies;
   i. Calculate the product of the constants $K_K \cdot f_c$ [2]
   ii. What would be the consumption of energy needed to crush the same material of average size 75 mm to an average size of 25 mm? [2]
c) Assuming that the size range involved can be considered coarse, which of these results would be regarded as being more reliable? [2]

QUESTION 5: CRUSHING [10]

A roll mill is available with rolls of 400mm diameter, and capable of milling to an average product particle size diameter of 0.05 mm. If the coefficient of friction for the material on the rolls is 0.12 and the angle of nip is 30°, what is the largest diameter of the feed particle that could be fed into the mill?

QUESTION 6: CONVEYOR BELT APPLICATION [20]

A belt conveyor 0.75 m wide and running at a speed of 1.81 m/s carries material of bulk density 0.9 t/m^3 up a gradient of 1 in 30 and then horizontally at the rate of 300 t/h. The maximum working stress in the 5 ply cotton belting is 5.25 kN/m ply and the length of the horizontal section of the belt is 80 m. The mass of moving parts of the empty conveyor is 60 kg/m, the idler friction coefficient is 0.03, and the two drum drive-head has non-slip ratio of 6.8 to 1. The figure below depicts a diagrammatic representation of the conveyor belt.



Determine the following;

a) The maximum tension (in kN) that can be supported by the belt. [2]

b) Maximum effective tension (in kN) that can be supported by the belt. [2]

c) The maximum total power required in kW. [2]

d) The power (in kW) required to drive the empty belt as a function of the length of the incline section of the belt, l_3. [4]

e) The power (in kW) required to raise the material to the required height as a function of the length of the incline section of the belt, l_3. [4]

f) The power (in kW) required to convey the material as a function of the length of the incline section of the belt, l_3. [4]

g) The maximum permissible length (in m) of the incline section of the belt, l_3. [2]

END OF EXAM

++++++++++++++++++++++++++++===================================++++++++++++++++++++++++++++

FORMULA SHEET

STRENGTH OF MATERIALS

$$\sigma = E \cdot \varepsilon \qquad \sigma = \frac{F}{A}$$

PARTICLE SIZE REDUCTION

Kick's Law $E = K_K \cdot f_c \cdot \log_e\left(\frac{L_1}{L_2}\right)$ or $E = K_K \cdot f_c \cdot \ln\left(\frac{L_1}{L_2}\right)$

Rittinger's Law $E = K_R \cdot f_c \cdot \left(\frac{1}{L_2} - \frac{1}{L_1}\right)$

Bond's Law $E = E_i \cdot \left({}^{100}/_{L_2}\right)^{1/2} \cdot \left(1 - {}^{1}/_{q^{1/2}}\right)$ with $q = \frac{L_1}{L_2}$

Specific surface area $V_P = p \cdot D_P^3$ $A_P = 6 \cdot q \cdot D_P^2$ **Shape factor** $\lambda = \frac{q}{p}$

MATERIAL HANDLING

Tensions ratio for a flat conveyor belt $T_1 = T_2 e^{\mu\theta}$

Tensions ratio for a v-conveyor belt $T_1 = T_2 e^{\frac{\mu\theta}{\sin(\frac{\phi}{2})}}$ **Effective belt tension** $T_e = T_1 - T_2 = \frac{P_T}{v}$

Maximum belt tension $T_1 = T_e \frac{e^{\mu\theta}}{e^{\mu\theta} - 1} \Rightarrow T_1 = T_e \frac{e^{\mu\theta}}{e^{\mu\theta} - 1}$ with $n = e^{\mu\theta}$

Maximum permissible belt stress $\sigma = \frac{T_1}{W \cdot p}$

Power required at the driving drum $P_T = T_e v = (T_1 - T_2)v = T_1\left(1 - \frac{1}{e^{\mu\theta}}\right)v$ & $P_T = P_e + P_m \pm P_r$

Motor power $P = \frac{P_T}{\eta}$

Power required to drive the empty belt $P_e = F_e v = m_i(l + 45)g\mu_e v$

Power required to convey material $P_m = m_m g l \mu_m v$

Power required to raise material $P_r = (Cap)gh$