

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATIONS, APRIL 2001
FOURTH YEAR – PROGRAMS 8 AND 6

MMS 412S – UNIT PROCESSES IN MATERIALS PROCESSING
(MONDAY APRIL 16, 2001)
2:00 P.M.

EXAMINERS: R. BERGMAN
I.D. SOMMERVILLE

ATTEMPT FIVE QUESTIONS, INCLUDING AT LEAST TWO FROM EACH
SECTION. USE SEPARATE BOOKS FOR EACH SECTION.
ALL QUESTIONS ARE OF EQUAL VALUE.

SECTION 1

Marks

1. Nickel sulphide ore is mined in the Sudbury area as a mixed copper nickel sulphide. The product from the Sudbury smelter operations is a matte composed of Ni_3S_2 and Cu_2S with small amounts of iron present. You are asked to select a process by which this matte can be produced from the ore.
- 5 A. Draw a flowsheet for the process you have selected
- 5 B. Write a brief explanation of the functions of each process step
- 5 C. Calculate the chemical composition of the matte (Ni, Cu, S) that contains 50 % copper.
- 5 D. Why is metallic nickel not normally produced by the converting process?

DATA:	Atomic weights	Ni	58.7
		Cu	63.5
		S	32.0

2. Magnesium is produced by the Pidgeon Process as a vapour by the reduction of dolomite with ferrosilicon. According to the reaction:



- 10 A. What is the vapour pressure of magnesium in mm Hg when the reaction is carried out at 1200 °C ?
- 5 B. What other process are used to produce magnesium. Give one example. Draw a flowsheet for the process you have selected and describe it briefly.
- 5 C. How much 50% Si ferrosilicon in kg is required to produce one (1) kg of magnesium ?

DATA:	Atomic weights	Fe	55.85
		Si	28.0
		Mg	24.3

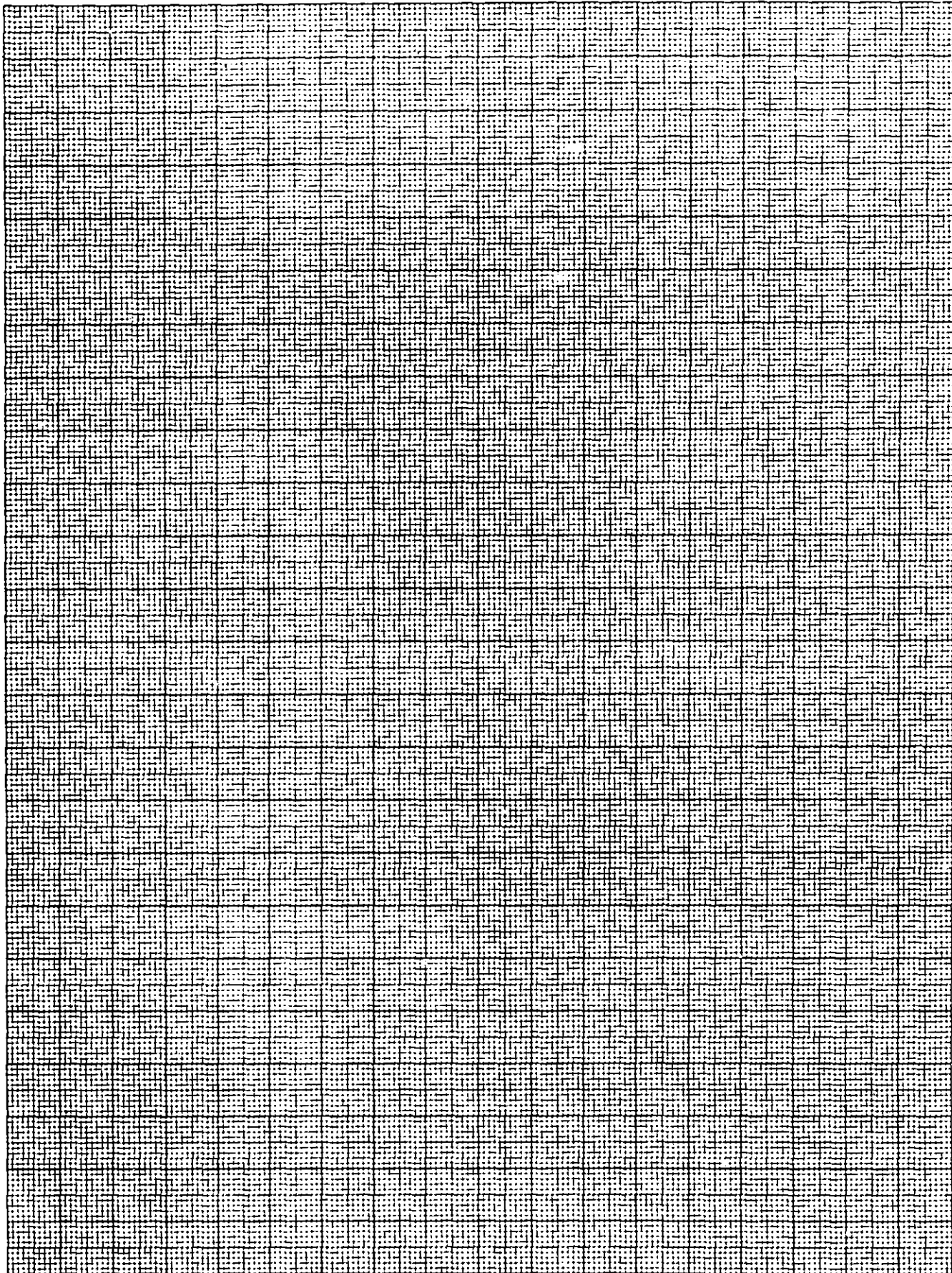
$$\log k = - \frac{\Delta G^\circ T}{4.575 * T}$$

3. Zinc occurs in nature as a sulphide, ZnS. A number of processes can be used by which zinc metal can be produced from the ore.
- 5 A. Select one process and draw the flowsheet for it
- 5 B. Write a brief explanation on the function of each process step.
- 5 C. How much energy is required to recover 1000 kg of zinc metal from a zinc sulphate solution. The cell voltage is 2.7 volts and the current efficiency is 95 % ?
- 5 D. How would you remove Cu and Co from a zinc sulphate solution? Explain how this process works.

DATA: Atomic weight Zn 65.4
26.8 Ah will deposit one gram equivalent.

SECTION 2

- 14 4. Outline the reasons for the development of direct reduction processes and describe one such process in reasonable detail.
- 6 Indicate the benefits from using some direct reduced iron to replace scrap in the charge to the Electric Arc Furnace.
- 12 5. Describe the reaction conditions during Basic Oxygen Furnace steelmaking, mentioning the factors which lead to the very rapid decarburisation observed in this process.
- 8 Indicate briefly some of the changes to Electric Furnace steelmaking which are allowing it to achieve decarburisation rates comparable to those in the BOF.
- 10 6. (a) Discuss the reasons for the attainment of very high levels of desulphurization in the ladle after steelmaking.
- 10 (b) Given the following data, calculate and plot the relationship between the dissolved oxygen and aluminum contents in steel at 1600°C, in equilibrium with (1) pure alumina, and (2) a calcium aluminate slag containing 50% CaO and 50% Al₂O₃, where the activity of alumina is 0.064. Use dissolved oxygen contents up to 50 ppm.
- Data: $[\%Al]^2 \cdot [\%O]^3 = 2 \cdot 10^{-14}$ at 1600°C, in equilibrium with pure alumina.
- 20 7. Discuss the important parameters in the design and operation of tundishes during the continuous casting of steel to achieve the optimum quality of the liquid steel immediately prior to casting.



10 MM CM