UNIVERSITY
OF
JOHANNESBURG

FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT

SCHOOL OF MINING, METALLURGY AND CHEMICAL ENGINEERING

DEPARTMENT OF METALLURGY

BACHELOR OF ENGINEERING TECHNOLOGY

REFRACTORY TECHNOLOGY THIRD YEAR BENGTECH

SECOND SEMESTER FINAL EXAMINATION

TOTAL MARKS: 100

WEIGHT	:	**60**
EXAMINER	:	**MR. G.U. OKEREAFOR**
MODERATOR	:	**DR. M.B SHONGWE**
NUMBER OF PAGES	:	**8 PAGES**
DATE	:	**NOVEMBER 2019**
DURATION	:	**180 MINUTES**
INSTRUCTION	:	**ATTEMPT ALL QUESTIONS FROM SECTIONS A & B.**
		PLEASE USE THE MULTIPLE-CHOICE ANSWER SHEET FOR SECTION A.

SECTION A

MULTIPLE CHOICE QUESTIONS

[40 Marks]

Question 1: Hot metal runner in blast furnace are lined with _____ bricks.

A. silica
B. carborundum
C. fireclay
D. magnesite

Question 2: Spray test determines the _____ of refractories.

A. resistance to slag penetration
B. resistance to CO attack
C. RUL
D. permanent linear change

Question 3: A steel member used in a furnace construction to take the thrust of the brickwork is called

A. buckstay
B. breast wall
C. armouring
D. baffle

Question 4: With increase in the porosity, thermal spalling resistance of fireclay brick

A. increases
B. decreases
C. remains same
D. may increase or decrease

Question 5: Thoria is an expensive refractory material and is radioactive in nature. Thorium oxide is used in the manufacture of

A. segar cones.
B. muffles for muffle furnaces.
C. insulating bricks.
D. crucibles used for melting of high purity metals.

Question 6: Water content in ground refractory material to be shaped into bricks by hand moulding is about _____ percent.

A. 5
B. 20
C. 40
D. 55

Question 7: Which one expands on heating?

A. Silica bricks
B. Fireclay bricks
C. Both (1) & (2)
D. Neither (1) nor (2)

Question 8: Refractoriness/fusion points of 'superduty' refractories is _____ °C.

A. 1520-1630
B. 1630-1670
C. > 1730
D. > 2000

Question 9: Presence of MgO in alumino-silicate refractories _____ its refractoriness.

A. increases
B. lowers
C. does not affect
D. either (1) or (2); depends on its quantity

Question 10: Spalling of silica bricks occurs due to abrupt volume changes, when it is cooled below a temperature of _____ °C.

A. 770
B. 570
C. 270
D. 70

Question 11: Thermal diffusivity of a refractory brick is high, when its _____ is high.

A. density
B. specific heat
C. thermal conductivity
D. none of these

Question 12: High porosity refractory bricks have

A. poor resistance to the peneration of molten slag, metal & flue gases.
B. poor heat conductivity & low strength.
C. better thermal spalling resistance.
D. all (1), (2) and (3).

Question 13: Which is the stable form of silica below 870°C?

A. Tridymite
B. Cristobalite
C. Quartz
D. None of these

Question 14: Beryllia (which is used in making crucibles for melting uranium thorium) is superior to alumina in all respects for high temperature (> 1900°C) use, except

A. cost
B. electrical conductivity
C. thermal conductivity
D. fusion point

Question 15: Firing of refractory brick is done to

A. dehydrate the dried refractory.
B. develop stable mineral forms in them.
C. form ceramic bonds necessary for development of high crushing strength in the finished product.
D. all (1), (2) and (3).

Question 16: Chemically, mullite refractories is

A. $3Al_2O_3.2SiO_2$
B. Al_2O_3
C. $ZrSO_4$
D. ThO_2

Question 17: Capacity of a refractory brick to withstand-sudden changes in temperature is denoted by the property called

A. spalling resistance.
B. refractoriness.
C. refractoriness under load (RUL).
D. none of these.

Question 18: Magnesite bricks are used in those parts of furnaces, which are

A. subjected to temperature fluctuation.
B. required to resist corrosive basic slag.
C. subjected to high load.
D. none of these.

Question 19: Resistance to slag attack of a refractory

A. depends on the nature of slag & refractory.
B. decreases at higher temperature.
C. decreases, if defective joints & cracks exist in the refractory.
D. all (1), (2) and (3).

Question 20: RUL of refractories depends on the

A. chemical composition.
B. physical structure.
C. presence of impurities like iron & alkali.
D. all (1), (2) and (3).

SECTION B

ATTEMPT ALL QUESTIONS

[60 Marks]

QUESTION 1

1.1 Part of the expectations in refractory technology is the use of appropriate terminologies in describing processes and situations. As a demonstration of your understanding of key terminologies as used in general refractory, define the following thermodynamic terms.

I. System
II. Surrounding
III. Universe
IV. Open system
V. Closed system
VI. Isolated system
VII. Cycle
VIII. Isothermal process
IX. Isobaric process
X. Isochoric/isometric

[20 Marks]

QUESTION 2

2.1 Describe in details the 4 processes in a carnot cycle **[8 Marks]**

2.2 Thermal conductivity can be defined as the quantity of heat transmitted through a material in unit time, per unit temperature gradient along the direction of flow and unit cross sectional area. Discuss 3 factors affecting the thermal conductivity of refractories.

[6 Marks]

2.3 A hypothetical Carnot engine operates between temperature limits of 260 °C and 30 °C. It is desired to increase the thermal efficiency by 20%. Assuming that the minimum temperature remains constant, what should the new maximum temperature be?

[6 Marks]

QUESTION 3

3.1 A company, Emerging Construction Company, has invented the worlds' ONLY – as far as they know - compounding lining technology as part of her 4IR inventions.

Several refractory materials such as baked carbon blocks, self – baking carbon block, ceramic brickwork as shown in Figure 1, are compounded and they were able to select different materials to construct the hearth and bottom section of the furnace.

What merits does this technology offer customers that is different to conventional lining techniques? [10 Marks]

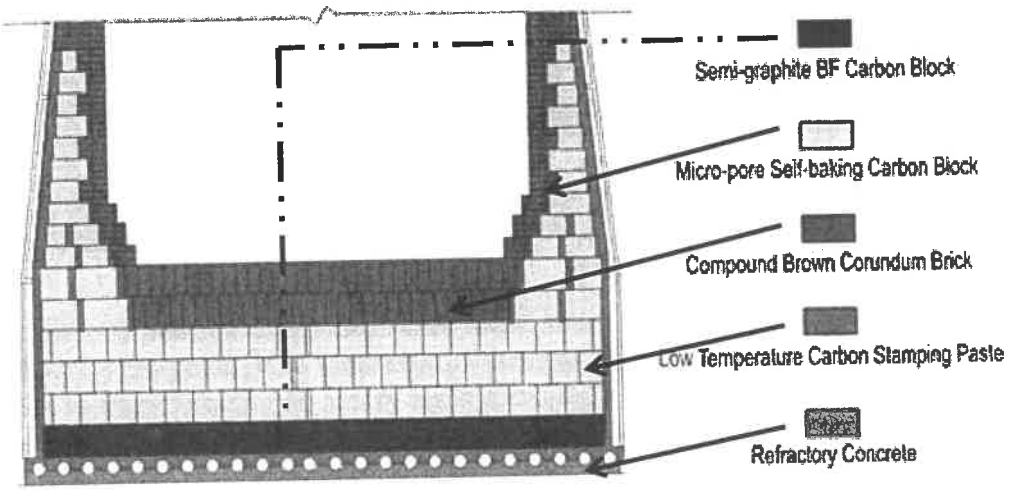

Figure 1: Lining Structure of a blast furnace (Bottom and Hearth) 402 m^3, in SISCOL, India (http://www.hieng.ir/%D8%AF%D8%A7%D9%86%D9%84%D9%88%D8%AF.html)

3.2 A thermal insulator is a poor conductor of heat, and has low thermal conductivity. Thermal insulation in refractory materials is of great importance. With reference to Figure 2, explain why? [5 Marks]

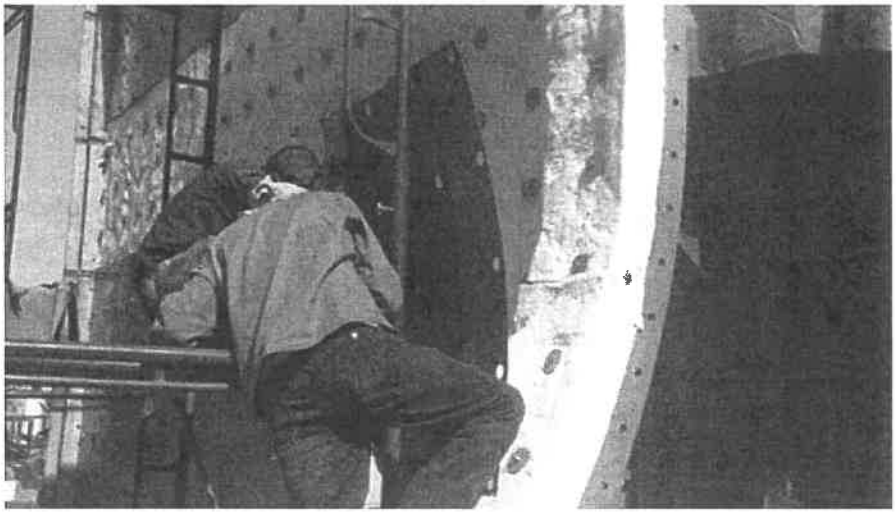

Figure 2: Converting Stone Wool to Refractory Ceramic Fiber Blanket Insulation (http://www.ceramicindustry.com/articles/94540-case-study-converting-stone-wool-to-refractory-ceramic-fiber-blanket-insulation)

3.3 Suppose we have a furnace lined with Super duty refractory brick, and the total wall area of this furnace is 125.4 m² and also suppose the refractory lining thickness is 30.48cm. Say, the process we are conducting in this furnace keeps its hot-face temperature at 1649°C. With thermocouples we find that the cold-face is at a steady temperature of 316°C. Then, what will be the rate of heat loss through the walls of this furnace?

[5 Marks]

k for super duty brick = 9.5

Given the equation: $Q = \frac{H}{t}$

Calculate Q.

Hint – Expand the equation in order to be able to use k, that is

$$\frac{H}{t} = Q = \frac{A\ (Change\ in\ T)}{x} * k$$

K = numerically equal to the rate of heat transport when the slab area (here, area of the refractory or furnace wall) is exactly 1 cm^2 and the temperature gradient is exactly $1^{O}C/cm$