SCHOOL OF MINING, METALLURGY & CHEMICAL ENGNEERING

DEPARTMENT OF METALLURGY

BEng Tech: Physical Metallurgy

SUBJECT:	**Welding Technology**
CODE:	**WLDMTB3**
ASSESSMENT:	**Supplementary Exam 2019**
WEIGHT:	**40:60**
EXAMINAR:	**Prof. P.A. Olubambi**
MODERATOR:	**Dr. Nthabiseng Maledi**
DATE:	**Tuesday, November 12, 2019**
DURATION:	**3 hours**
TIME:	**12:30 – 15:30**
VENUE:	**G210, DFC Q/K Building**
TOTAL MARKS:	**120**

INSTRUCTIONS:

- **Use the appendices provided at the end of the question paper to answer some of the questions**
- **Scientific calculator is permitted**
- **Answer all the questions**

Question 1

a) As a renowned metallurgical engineering consultant with key competencies in serving aerospace, automotive and ship building industry, there is a problem of selecting the appropriate welding process for creating a large butt joint of Aluminium parts, you are being contacted to offer solution to this problem. Answer the question based on:

- **i.** Which process you would recommend? **(1 mark)**
- **ii.** Is the selected process a type of fusion or solid-state welding? **(1 mark)**
- **iii.** List two (2) advantages of the selected process **(2 marks)**
- **iv.** Give a schematic representation of this process (**3 marks)**

b) Define solid-state welding (SSW) and mention the two key factors for a successful solid-state welding operation. **(3 marks)**

c) With good schematic illustration, explain the following types of solid-state welding and give a specific area of application:

- **i.** Cold welding (**5 marks)**
- **ii.** Rolling welding **(5 marks)**
- **iii.** Friction welding **(5 marks)**

Question 2

a) Oxy-acetylene welding involves the chemical reaction between fuel gas (acetylene) and oxygen, explain the following chemical equations based on the oxy-acetylene welding operation:

$C_2H_2 + O_2 \rightarrow 2CO + H_2 + \text{heat}$ **(1 marks)** … Eq. 2.0

$2CO + H_2 + 1.5O_2 \rightarrow 2CO_2 + H_2O + \text{heat}$ **(2 marks)** … Eq. 2.1

b) Despite welding being utilized as one of the most popular industrial fabrication processes in numerous engineering applications, there are some critical general safety precautions that needs to be observed when performing welding operation, therefore mention six (6) general welding safety precautions and four (4) hazards associated with welding. **(10 marks)**

c) Welding defects can impair the usefulness of a weldment. With excellent pictorial representation, explain three (3) different types of welding defects in terms of causes and remedies. **(12 marks)**

Question 3

a) Given the figure 1. below, considering 304 SS as the base metal for A and B, while using 308L SS as the filler metal D, compute the dilution percentage for the following scenarios:

i. High dilution **(4 marks)**

Parameters	**a**	**b**	**d**
Value (units^2)	0.25	0.25	0.5

Parameters	**a**	**b**	**d**
Value (units^2)	0.25	0.2	0.55

ii. Low dilution **(2 marks)**

Parameters	**a**	**b**	**d**
Value (units^2)	0.1	0.1	0.8

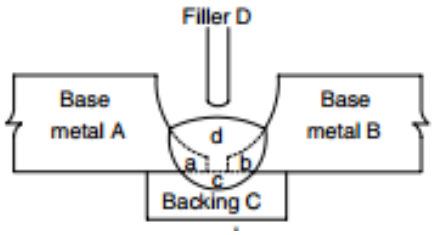


Figure 1.

b) When two separate base metals are joined together via fusion welding, a weld is formed. Explain with the aid of a diagram, the following:

i. Unmixed Zone (UMZ) **(2 marks)**
ii. Factors influencing the formation of UMZ **(2 marks)**
iii. Partially Melted Zone (PMZ) **(2 marks)**
iv. Heat Affected Zone (HAZ) **(2 marks)**

c) There are several types of fusion welding used in the industry and arc welding is one of the popular process. Discuss the following types of arc welding with adequate pictorial illustration by focusing on principles and areas of application.

i. SMAW (Shielded Metal Arc Welding) **(3 marks)**
ii. GMAW (Gas Metal Arc Welding or MIG welding) **(3 marks)**
iii. GTAW (Gas Tungsten Arc Welding or TIG Welding) **(3 marks)**

d) List four (4) separate parts used in oxy-acetylene gas welding setup. **(2 marks)**

Question 4

a) A gas tungsten arc welding operation is performed at a current of 300 A and voltage of 20 V. The melting factor $f_2 = 0.5$, and the unit melting energy for the metal $U_m = 10$ J/mm^3. Determine the:

i. Power in the operation, **(2 marks)**
i. Rate of heat generation at the weld, **(2 marks)** and
ii. Volume rate of metal welded. **(2 marks)**

Use the gas tungsten arc welding heat transfer factor f_1 of 0.7 for this operation.

b) The power source in a typical welding setup generates 4500 W that can be transferred to the work surface with a heat transfer factor 0.7. The metal to be welded is low carbon steel, whose melting temperature is 1760^0K. Given that the melting factor in this operation is 0.5. If a continuous fillet weld is to be made with a cross-sectional area of 20 mm^2, determine the travel speed at which the welding operation can be accomplished. Use the value for *constant K* in the unit energy equation as 3.33×10^{-6} **(6 marks)**

c) A heat source transfers 3000 J/sec to a metal part surface. The heated area is circular, and the heat intensity decreases as the radius increases: 75% of the heat is concentrated in a circular area that 3.5 mm in diameter. What is the power density for melting? **(3 marks)**

d) Use the table in table 1 to compute the unit energy for steels/Ti: *K constant* = 3.33×10^{-6}

Steels	Melting Temperature ^{0}K	S/N
a) Low Carbon	1760	1
b) Medium Carbon	1670	2
c) High Carbon	1650	3
d) Low Alloy	1700	4
e) Titanium (Ti)	2070	5

Table 1.

(10 marks)

Question 5

a) Explain the procedure involved in using the following NDT in establishing the quality of a weld:

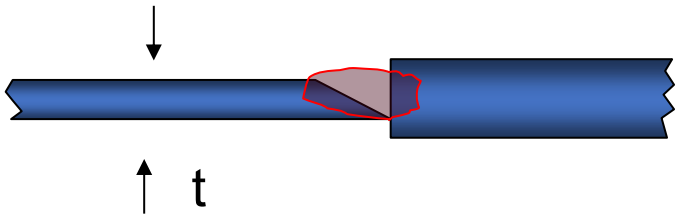
I. Visual Inspection (VT). **(2 marks)**
II. Radiographic Inspection. **(2 marks)**
III. Magnetic Particle Inspection (MT). **(2 marks)**
IV. Liquid Penetrant Inspection (PT). **(2 marks)**
V. Ultrasonic Inspection (UT). **(2 marks)**

b) Using the table provided in the appendices together with the condition listed with it, what is the:

a. Maximum weld size and **(3 marks)**
b. Minimum weld size of the weld design shown below. (**2 marks)**:

Note : *(maximum weld size is controlled by thin plate while, minimum weld size is controlled by thick plate).*

c) If the effective area of a weldment (shown below) is 5.5 sq. in and the throat thickness is 1/4 in, compute the length of the weld **(5 marks).**



Appendices

TABLE J2.4
Minimum Size of Fillet Welds

Material Thickness of Thinner Part Joined, in. (mm)	Minimum Size of Fillet Weld,[a] in. (mm)
To 1/4 (6) inclusive	1/8 (3)
Over 1/4 (6) to 1/2 (13)	3/16 (5)
Over 1/2 (13) to 3/4 (19)	1/4 (6)
Over 3/4 (19)	5/16 (8)

[a] Leg dimension of fillet welds. Single pass welds must be used.
Note: See Section J2.2b for maximum size of fillet welds.

The maximum size of fillet welds of connected parts shall be:

(a) Along edges of material less than 1/4-in. (6 mm) thick, not greater than the thickness of the material.

(b) Along edges of material 1/4 in. (6 mm) or more in thickness, not greater than the thickness of the material minus 1/16 in. (2 mm), unless the weld is especially designated on the drawings to be built out to obtain full-throat thickness. In the as-welded condition, the distance between the edge of the base metal and the toe of the weld is permitted to be less than 1/16 in. (2 mm) provided the weld size is clearly verifiable.

- Effective area of groove weld:

$$A_w = t_e \times L_w$$

A_w = Effective area of weld.

t_e = Effective throat thickness.

L_w = Length of weld.