UNIVERSITY OF GHANA

BSc. (ENG) MATERIALS SCIENCE AND ENGINEERING

END OF SECOND SEMESTER EXAMINATIONS: 2016/2017

SCHOOL OF ENGINEERING SCIENCES

MATERIALS SCIENCE AND ENGINEERING DEPARTMENT

MTEN 324: METAL JOINING TECHNOLOGY (2 CREDITS)

Answer ALL Questions **TIME ALLOWED: 2 HOURS**

1. Define the following terms as applied to metal joining technology;
   a. Autogenous weld
   b. Boxing
   c. Welding
   d. Crater
   e. Dilution
   f. Fixture
   g. Layer
   h. Tack weld
   i. Spot welding
   j. Electrode bare **[20 marks]**
2. Give brief description of the following welding processes;
   a. Oxy-acetylene welding
   b. Gas tungsten arc welding
   c. Gas metal arc welding
   d. Shielded metal arc welding
   e. Plasma arc welding **[20 marks]**

3. Write out from A – K the missing parts of a weld bead in Figure 1.

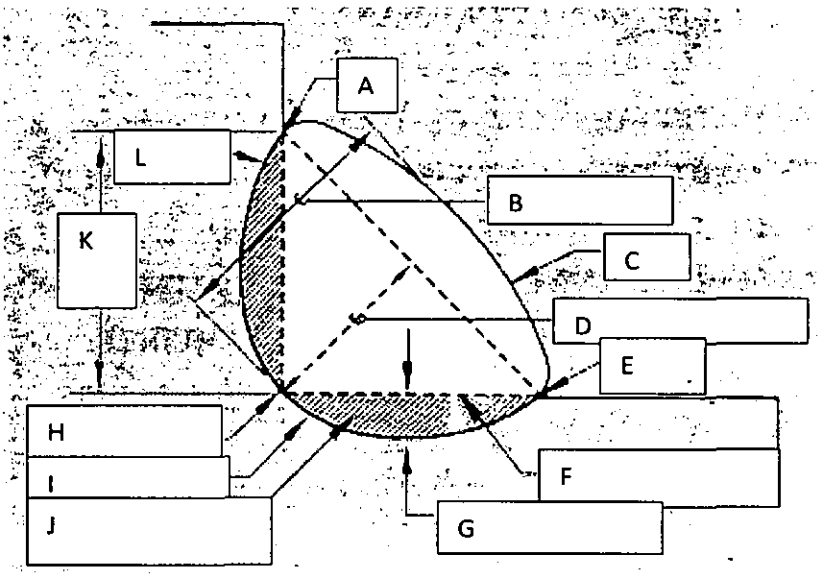

Figure 1: The weld bead. **[11 marks]**

4.

a. Metallurgically, the weld metal zone is divided into six zones. Name and explain them. **[9 marks]**

b. Distinguish between heterogenous and autogenous welds. **[8 marks]**

c. State five (5) major differences between weld solidification and ingot solidification. **[10 marks]**

d. The solidification front structures are shown in Figures 2 & 3. Identify and briefly explain your observations.

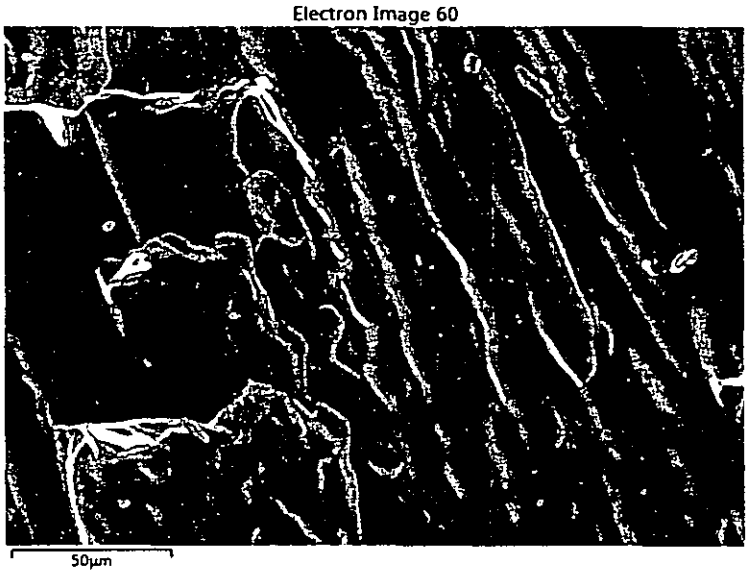

Figure 2: Solidification front structure of unstabilized ferritic stainless steel [top view] (× 550).

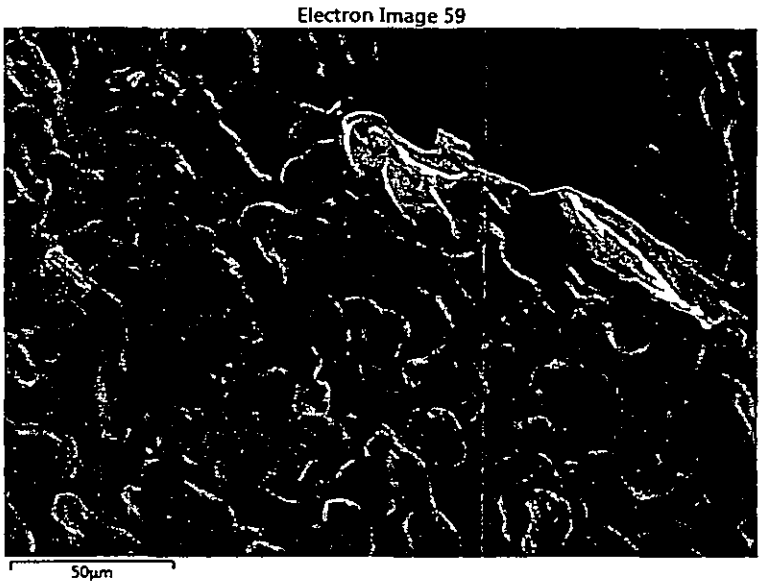

Figure 3: Solidification front structure of unstabilized ferritic stainless steel [top view] (× 550). **[8 marks]**

5. Calculate the temperature of the heat-affected zone (at a distance r = 15 mm from the centre of the weld) during the welding of copper alloy as a function of time for both the thick and thin plate solutions. Assume the welding parameters of 350A, 20V and a welding speed of 10 mm/s in both cases and a plate thickness of 4 mm for the thin plate

solution. Take the efficiency of the welding equipment to be 0.6. Fill in the table for the thick and thin plates shown in Table 1. Table 2 is the material properties.

Thick $$T_p - T_o = \frac{q/v}{2\pi\rho t}\exp\left(-\frac{r^2}{4at}\right)$$ Eqn 1

Thin $$T_p - T_o = \frac{q/v}{d\sqrt{4\pi\lambda\rho ct}}\exp\left(-\frac{r^2}{4at}\right)$$ Eqn 2

Thick: $$T_p - T_o = \left(\frac{2}{\pi e}\right)\frac{q/v}{\rho c r^2}$$ Eqn 3

Thin: $$T_p - T_o = \sqrt{\frac{2}{\pi e}}\,\frac{q/v}{d\rho c 2r}$$ Eqn 4

Table 1: The time - temperature table for the thick and thin plate thickness

Time (s)	Temperature (K) [Thick]	Temperature (K) [Thin]
0.5		
1		
2		
3		
4		
5		

Table 2: Material properties

Material	*Volume thermal capacity* $\rho c\ (Jm^{-3}K^{-1})$	*Thermal diffusivity* $a\ (m^2s^{-1})$	*Thermal Conductivity* $\lambda\ (Jm^{-1}s^{-1}K^{-1})$	*Melting point (K)*
Aluminium	2.7×10^6	8.5×10^{-5}	229.0	933
Carbon steel	4.5×10^6	9.1×10^{-6}	41.0	1800
9% Ni steel	3.2×10^6	1.1×10^{-5}	35.2	1673
Austenitic steel	4.7×10^6	5.3×10^{-6}	24.9	1773
Inconel 600	3.9×10^6	4.7×10^{-6}	18.3	1673
Ti alloy	3.0×10^6	9.0×10^{-6}	27.0	1923
Copper	4.0×10^6	9.6×10^{-5}	384.0	1336
Monel 400	4.4×10^6	8.0×10^{-6}	35.2	1537

[20 marks]