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## UNIVERSITY OF GHANA

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### BSC. MATERIALS SCIENCE AND ENGINEERING

### SECOND SEMESTER EXAMINATIONS: 2016/2017

### DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

### SCHOOL OF ENGINEERING SCIENCES

**MTEN 402: NONDESTRUCTIVE EVALUATION AND FAILURE ANALYSIS (2 CREDITS)**

**TIME ALLOWED: TWO (2) HOURS**

#### INSTRUCTIONS:

**NO ANSWER BOOKLET REQUIRED. ANSWER ALL QUESTIONS ON THE QUESTION PAPER BY CIRCLING THE LETTER CORRESPONDING TO THE APPROPRIATE OPTION. USE THE EXTRA SHEET ATTACHED TO SHOW CALCULATIONS.**

1. POD stands for:
  - a. Product of discontinuities
  - b. Probability of defects
  - c. Probability of detection
  - d. Personnel over distributor
  
2. Light intensity measurements are made using a:
  - a. Refractometer
  - b. Radiometer
  - c. Pie gauge
  - d. UV meter
  
3. Water soluble developers consist of a group of chemicals that are:
  - a. Saturated in water and experience a chemical shift allowing it to fluoresce on the parts surface
  - b. Only used on rough porous surfaces
  - c. Dissolved in water
  - d. Not to be used on galvanized parts
  
4. Which type of developer is considered the most sensitive?
  - a. Water suspendable
  - b. Water soluble
  - c. Dry powder
  - d. Non aqueous wet

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- 5 The water content of water washable penetrant:s:
  - a. Should be performed daily
  - b. Should be performed weekly
  - c. Should be performed monthly
  - d. Must be checked regularly
- 6 Which of the following should be removed in order to obtain a good penetrant test?
  - a. Varnish
  - b. Oxides
  - c. Plating
  - d. All of the above
- 7 A penetrant must:
  - a. Change viscosity in order to spread over the surface of the part
  - b. Spread easily over the surface of the material
  - c. Have a low flash point
  - d. Be able to change colour in order to fluoresce
- 8 When fluorescent penetrant inspection is performed, the penetrant materials are formulated to glow brightly and to give off light at a wavelength:
  - a. Close to infrared light
  - b. Close to the wavelength of x-rays
  - c. That the eye is most sensitive to under dim lighting conditions
  - d. In the red spectrum
- 9 When a permanent record is required which type of developer can be used:
  - a. Lacquer developer
  - b. Nonaqueous developer
  - c. Layered developer
  - d. Peeling developer
- 10 Dry developer can be applied:
  - a. To a wet part
  - b. To a partially wet part but needs to be placed in a dryer immediately
  - c. To a dry part
  - d. All of the above
- 11 Which type of current flows continuously in one direction at a constant voltage?
  - a. Direct current
  - b. Alternating current
  - c. Rectified alternating current
  - d. Half wave rectified alternating current
- 12 Magnetic particle inspection can be performed on parts made from which materials?
  - a. Iron, nickel, copper
  - b. Iron, nickel, cobalt

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- c. Nickel, cobalt, copper
  - d. Iron only
- 13 A material with a narrower hysteresis loop has:
- a. Higher permeability
  - b. Lower retentivity
  - c. Lower coercivity
  - d. All of the above
- 14 The force required to remove the residual magnetism from the material is called the:
- a. Inverse force
  - b. Reciprocal force
  - c. Coercive force
  - d. Residual force
- 15 Which of the following has a very weak and negative susceptibility to magnetic field?
- a. Ferromagnetic materials
  - b. Diamagnetic materials
  - c. Paramagnetic materials
  - d. None of the above
- 16 Magnetic lines of force:
- a. Have the same strength
  - b. Seek the path of least resistance
  - c. Decrease in density with increasing distance from the poles
  - d. All of the above
- 17 Multidirectional inspection equipment:
- a. Provides a more sensitive inspection
  - b. Provides a less sensitive inspection
  - c. Can be used without the need for QQIs
  - d. Reduces inspection time
- 18 A yoke establishes a magnetic field:
- a. That can be constant or pulsed
  - b. Between the north and south poles of the yoke
  - c. Equally in all directions around the poles
  - d. Both A and B
- 19 Faraday's Law of Magnetic Induction states that:
- a. The flow of electrons can be used to generate a magnetic field
  - b. The magnetic forces of the material's electrons will be affected by an external magnetic field
  - c. Iron filings can be used to produce an indication of a flaw
  - d. Flux leakage is the by-product of magnetic fields when testing aluminium alloys.
- 20 The use of prods is sometimes restricted because:
- a. They produce a relatively weak field

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- b. There is a potential for arcing that could damage parts
  - c. It is not possible to control the field orientation
  - d. None of the above
- 21 Narrow EDM notches and saw cuts:
- a. Are never used because they are too wide
  - b. Are never used due to their heat affected zones
  - c. Are commonly used to represent cracks
  - d. Both A and B
- 22 Sliding probes are used to test:
- a. Large flat surfaces
  - b. Inside bolt holes
  - c. In radiuses
  - d. Around the edges of fasteners
- 23 Which type of probe has a long slender housing to permit inspection in restricted spaces?
- a. Pancake probes
  - b. Pencil probes
  - c. Encircling probes
  - d. Sliding probes
- 24 Drilled holes are commonly used to represent:
- a. Pitting
  - b. Cracks
  - c. Delaminations
  - d. None of the above
- 25 Which component features should be similar to the reference standard?
- a. Material thickness
  - b. Material geometry
  - c. Material conductivity
  - d. All of the above
- 26 Some common classifications of probes include:
- a. Surface probes
  - b. Bolt hole probes
  - c. ID probes
  - d. All of the above
- 27 The depth of penetration is affected by:
- a. Magnetic permeability
  - b. Electrical resistivity
  - c. Probe drive frequency
  - d. All of the above

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28. When a probe is brought near a conductive but nonmagnetic material, the coil's inductive reactance will:
- Increase
  - Decrease
  - Remain the same
  - Remain the same until the probe touches the material
29. When maintaining constant liftoff is a problem, what type of probe should be used?
- A absolute probe
  - A differential probe
  - A reflection probe
  - Both B and C
30. Scanning speed must be controlled:
- When using a small transducer
  - When using a large transducer
  - When using a high pass filter
  - When using a large low frequency probe
31. Which type of screen presentation displays a plan-type view of the location and size of the test specimen features?
- A-scan
  - B-scan
  - C-scan
  - All of the above
32. DACC stands for:
- Distance Amplitude Correction Curve
  - Direct Application Correction Curve
  - Distance Area Correction Calculation
  - Distance Area Computer Controlled
33. Shear waves do not propagate in:
- Solids
  - Gases
  - Liquids
  - Both B and C are correct
34. What is used to support the active element and dampen the transducers characteristics?
- Resin
  - Oil
  - Backing material with a similar the impedance of the transducer
  - Any of the above will work
35. The first critical angle describes the condition where:
- The angle of the refracted longitudinal wave is less than  $90^\circ$
  - The angle of the refracted longitudinal wave is exactly  $90^\circ$
  - The angle of the refracted longitudinal wave is greater than  $90^\circ$

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- d. The angle of the refracted shear wave is exactly  $90^\circ$
- 36. Which material properties affect the speed of sound within a material?
  - a. Density and specific gravity
  - b. Atomic mass and density
  - c. Density and elastic properties
  - d. Acoustic impedance and atomic mass
- 37. What type of set-up can provide information about both the size of the flaw and distance between the flaw and the transducer?
  - a. Through transmission
  - b. Pitch/catch with two transducers
  - c. Pulse echo
  - d. Both B and C
- 38. Longitudinal waves are also called:
  - a. Surface waves
  - b. Pressure waves
  - c. Compressional waves
  - d. Both B and C are correct
- 39. The frequency marked on a transducer indicates:
  - a. The centre frequency at which the transducer operates
  - b. The range of the transducer's operating frequency
  - c. The highest frequency produced by the transducer
  - d. None of the above
- 40. Which of the following could influence the behaviour of a transducer?
  - e. Electrical construction
  - f. Material construction
  - g. Mechanical construction
  - h. All of the above
- 41. Who is given credit for the discovery of X-ray?
  - a. Henri Becquerel
  - b. Wilhelm Roentgen
  - c. Marie Curie
  - d. Pierre Curie
- 42. Newtons Inverse Square Law is useful in radiography because it indicates how the radiation intensity is affected by:
  - a. Radioactive decay
  - b. Distance from the source
  - c. The size of the source
  - d. None of the above

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43. After traveling through two half-value layers, the incident radiation has been reduced to:
- a. 50%
  - b. 35%
  - c. 20%
  - d. None of the above
44. Which of the following is not a strength of radiographic inspection?
- a. It is not limited to material type
  - b. It can be used to inspect assembled components
  - c. It can detect surface and subsurface features
  - d. Access to both side of the test sample is required
45. Computed tomography X-ray techniques allow the test component to be:
- a. Viewed in various cross-sectional slices
  - b. Viewed from different angles
  - c. Analyzed for chemical composition
  - d. None of the above
46. Exposure to ionizing radiation can be limited:
- a. With the use of shielding
  - b. By increasing distance form the source
  - c. By limiting the time exposed to the radiaiton
  - d. All of the above
47. Unexposed X-ray film is comprised of a plastic, transparent base coated with an emulsion containing radiation-sensitive particle known as:
- a. Metalic silver crystals
  - b. Silver halide grains
  - c. Both A and B
  - d. Neither A or B
48. Radiographic inspection should be used for crack detection only when:
- a. The crack is large
  - b. The test componet is a casting
  - c. The test component is a weldment
  - d. The orientation of the crack is known
49. X-rays and Gamma rays are often referred to as photons because:
- a. They possess a charge
  - b. They have mass
  - c. They occur as small packets of energy
  - d. None of the above
50. X-rays and Gamma rays are a form of:
- a. Light
  - b. Particle radiation
  - c. Electromagnetic radiation

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- d. Both B and C
- 51. The deformation of a material resulting from a static load under elevated temperature is termed as
  - a. Fatigue
  - b. Creep
  - c. Ductile fracture
  - d. Plastic deformation
- 52. The cup-and-cone fracture surface gives indication of
  - a. Ductile fracture
  - b. Brittle fracture
  - c. Extensive necking fracture
  - d. General cavity formation
- 53. On which of the following angles to the applied tensile axis is shear deformation likely to occur?
  - a.  $30^\circ$
  - b.  $45^\circ$
  - c.  $60^\circ$
  - d.  $90^\circ$
- 54. Chevron markings on a fracture surface are characteristics of
  - a. Brittle fracture
  - b. Ductile fracture
  - c. Plastic deformation
  - d. Fatigue fracture
- 55. The V-shaped Chevron markings on fracture surfaces point back toward
  - a. Crack growth
  - b. Transgranular fracture
  - c. Crack initiation site
  - d. Extensive necking
- 56. Which of the following microscopy techniques is preferred in fractographic examination
  - a. Optical microscopy
  - b. Wide field microscopy
  - c. Ultrasonic microscopy
  - d. Scanning electron microscopy
- 57. It is a measure of the degree to which an external stress is amplified at the flaw tip
  - a. Stress concentration
  - b. Stress raiser
  - c. Stress concentration factor
  - d. Fracture toughness
- 58. Which of the following may be beneficial to the fatigue life of a metal
  - a. Compressive surface residual stress



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- b. Tensile residual stress
  - c. Mean stress
  - d. Stress amplitude
59. What is the magnitude of the maximum stress that exists at the tip of an internal crack having a radius of curvature of  $2.5 \times 10^{-4}$  mm and a crack length of  $2.6 \times 10^{-2}$  mm when a tensile stress of 170 MPa is applied?
- a. 2554 MPa
  - b. 5428 MPa
  - c. 2452 MPa
  - d. 2833 Mpa
60. For questions 59 what is the magnitude of the stress concentration factor?
- a. 14.42
  - b. 17.00
  - c. 31.93
  - d. 22.00
61. A large plate is fabricated from a steel alloy that has a plane strain fracture toughness of 55 MPa $\sqrt{\text{m}}$ . If, during service use, the plate is exposed to a tensile stress of 200 MPa, What is the minimum length of a surface crack that will lead to fracture? Assume a value of 1.0 for Y.
- a. 4.2 mm
  - b. 24 mm
  - c. 42mm
  - d. 2.4 mm
62. A structural component in the form of a wide plate is to be fabricated from a steel alloy that has a plane strain fracture toughness of 77.0MPa $\sqrt{\text{m}}$  and a yield strength of 1400 MPa. The flaw size resolution limit of the flaw detection apparatus is 4.1 mm. If the design stress is one half of the yield strength and the value of Y is 1.0, determine the critical flaw size for this plate.
- a. 3.9 mm
  - b. 9.3 mm
  - c. 39 mm
  - d. 93 mm

*Use the following information to answer questions 63 – 65.*

A fatigue test was conducted in which the mean stress was 50 MPa and the stress amplitude was 225 MPa.

63. Compute the maximum and minimum stress levels.
- a. 293 MPa and -12 MPa
  - b. 180 MPa and 15 MPa
  - c. 216 MPa and -130 Mpa
  - d. 275 MPa and -175 MPa

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64. Compute the stress ratio.
  - a. -0.04
  - b. -0.64
  - c. +0.08
  - d. +0.50
65. Compute the magnitude of the stress range.
  - a. 450
  - b. 346
  - c. 135
  - d. 305
66. Which of the following may not be the cause of failures of metallic components?
  - a. Design shortcomings
  - b. Proper maintenance and repair
  - c. Material imperfections due to faulty processing or fabrication
  - d. Overloading and other service abuses
67. Which of the following is the most preferred technique for fractographic analysis?
  - a. Optical microscope
  - b. XRD
  - c. XRF
  - d. SEM
68. Which of the following techniques may be equipped with the Debye-Scherrer camera to help identify corrosion products and phases in refractories in minerals?
  - a. Optical microscope
  - b. Data Analysis
  - c. X-ray techniques
  - d. Metallographic techniques
69. Which of the following may not be classified as background information on a failed component?
  - a. Function of item
  - b. Service life at the time of failure
  - c. Performance rating of item
  - d. Fractograph
70. Which of the following is not appropriate produce to conduct failure analysis?
  - a. Assemble background
  - b. Perform visual examination of the failure area and adjacent areas to determine, photograph, and/or schematically record
  - c. Request for fractographic data
  - d. Perform chemical analyses

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SHOW CALCULATIONS ON THIS SHEET

**APPENDICES  
APPENDIX 7**

**THERMAL DATA FOR SOME FOOD PRODUCTS**

	Freezing point	Percent water	Specific heat		Latent heat of fusion
	(°C)		above freezing	below freezing	
			(kJ kg <sup>-1</sup> °C <sup>-1</sup> )		(kJ kg <sup>-1</sup> )
<b>Fruit</b>					
Apples	-2	84	3.60	1.88	280
Bananas	-2	75	3.35	1.76	255
Grapefruit	-2	89	3.81	1.93	293
Peaches	-2	87	3.78	1.93	289
Pineapples	-2	85	3.68	1.88	285
Watermelons	-2	92	4.06	2.01	306
<b>Vegetables</b>					
Asparagus	-1	93	3.93	2.01	310
Beans (green)	-1	89	3.81	1.97	297
Cabbage	-1	92	3.93	1.97	306
Carrots	-1	88	3.60	1.88	293
Corn	-1	76	3.35	1.80	251
Peas	-1	74	3.31	1.76	247
Tomatoes	-1	95	3.98	2.01	310
<b>Meat</b>					
Bacon	-2	20	2.09	1.26	71
Beef	-2	75	3.22	1.67	255
Fish	-2	70	3.18	1.67	276
Lamb	-2	70	3.18	1.67	276
Pork	-2	60	2.85	1.59	197
Veal	-2	63	2.97	1.67	209
<b>Miscellaneous</b>					
Beer	-2	92	4.19	2.01	301
Bread	-2	32-37	2.93	1.42	109-121
Eggs	-3		3.2	1.67	276
Ice cream	-3 to -18	58-66	3.3	1.88	222
Milk	-1	87.5	3.9	2.05	289
Water	0	100	4.19	2.05	335

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