SAMPLE EXAMINATION

The purpose of the following sample examination is to provide an example of what is provided on exam day by ASQ, complete with the same instructions that are provided on exam day.

The test questions that appear in this sample examination are retired from the CRE pool and have appeared in past CRE examinations. Since they are now available to the public, they will NOT appear in future CRE examinations. This sample examination WILL NOT be allowed into the exam room.

Appendix A contains the answers to the sample test questions. ASQ will not provide scoring and analysis for this sample examination. Remember: These test questions will not appear on future examinations so your performance on this sample examination may not reflect how you perform on the formal examination. A self-appraisal of how well you know the content for the specific areas of the body of knowledge (BOK) can be completed by using the worksheet in Appendix B.

On page 2 of the instructions, it states "There are 150 questions on this 4-hour examination." Please note that this sample exam only contains 75 questions.

If you have any questions regarding this sample examination, please email cert@asq.org

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NAME_____

CERTIFIED RELIABILITY ENGINEER

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General Instructions

All answers **must** be recorded on the Scantron Answer Sheet; no exam will be graded with the answers marked in the exam booklet.

1. Using a soft lead pencil (#2 or softer) only, blacken the circle of the correct answer. **Do not use ink**. If you change your answer, be sure to erase the previous answer completely.
2. Each question has **ONE** correct answer only.
3. This is a timed test, so do not linger over difficult questions. Instead, skip the questions that you are unsure of and return to them if you have time when you reach the end of the test.
4. Do not fold, staple, or tear the answer sheets.
5. Although this is an open-book examination and personally generated materials/notes from training or refresher courses **are** allowed, the following conditions apply:
   - Each examinee must make his/her reference materials available to the proctor for review.
   - Absolutely no collections of questions and answers or weekly refresher course quizzes are permitted. Reference sources that contain such copy are not allowed unless the questions and answers are removed or obscured. **Examples of such sources include but are not limited to refresher and preparatory primers.**
   - **Calculator Policy:** With the introduction of palmtop computers and the increasing sophistication of scientific calculators, ASQ has become aware of the need to limit the types of calculators that are permitted for use during the examinations. **Any silent, hand-held, battery-operated calculator WITHOUT an alphabetic keyboard will be permitted. However all programmable memory must be cleared from the calculator before you enter the exam room.** The examination is written so that a simple calculator will be sufficient to perform all calculations.
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6. When you have finished, check your answer sheet to be sure it is properly identified with your name and member number. Return your examination booklet, answer sheet, and scratch paper to your proctor. You must sign the roster sheet to signify the return of your test booklet.
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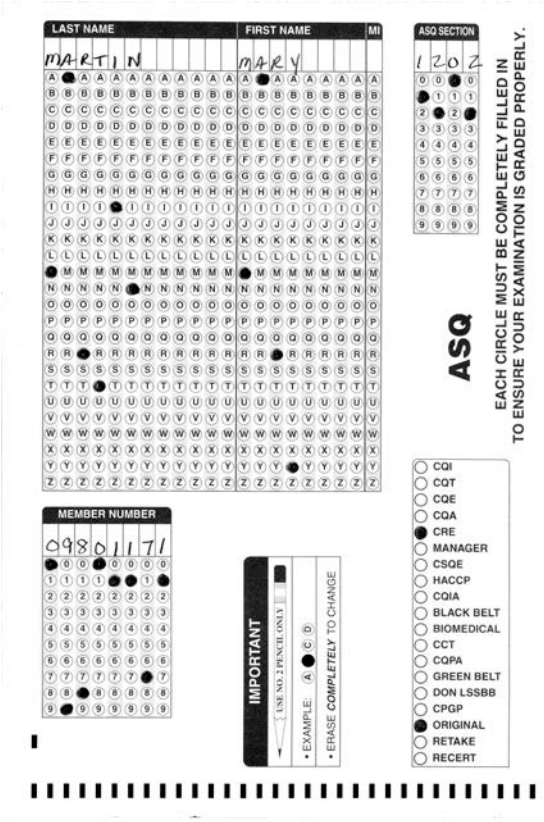
Special Instructions

1. **Please note that your answer sheet has been personalized with your name, member number, section number, and test type.**
2. **Do NOT make any changes to these parts of the answer sheet. Doing so will only delay your exam results. Instead notify the Proctor of any changes.**
3. **If you don't have a personalized answer sheet, see your Proctor for further instructions.**
4. **There are 150 questions on this four-hour examination.**



STOP

DO NOT CONTINUE UNTIL INSTRUCTED

CERTIFIED RELIABILITY ENGINEER Test

Directions: Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case and then fill in the corresponding space on the answer sheet.

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1. Which of the following methods will most improve the reliability of a product?

   (A) Reducing confidence levels
   (B) Reducing variation
   (C) Increasing sample size
   (D) Increasing test time

2. Which of the following methods can be used to quantitatively identify items that are risk-critical?

   (A) Design review
   (B) Fault-tree analysis
   (C) Concurrent engineering
   (D) Human reliability analysis

3. At the design stage of a product, the first safety focus should be on which of the following?

   (A) Regulatory requirements
   (B) Production tools
   (C) Controls and equipment
   (D) End-user applications

4. Which of the following statements is true about response surface methods?

   (A) They can eliminate day-to-day variations in a manufacturing environment.
   (B) They are more efficient than two-level factorial design techniques.
   (C) They do not require technical considerations to implement the method.
   (D) They determine how an output is affected by a set of variables over a specified region.

5. Which of the following assumptions is true about degradation?

   (A) It is inherent and irreversible.
   (B) It is inherent and reversible.
   (C) It is unacceptable and irreversible.
   (D) It is unacceptable and reversible.

6. A parts-count reliability prediction is calculated by summing only the

   (A) parts failure rates
   (B) number of parts in the system
   (C) variances of the part failure rates
   (D) parts failure rates with application stress

7. A part has a constant hazard rate. If preventive maintenance is used, the part's failure probability will be affected in which of the following ways?

   (A) It will increase.
   (B) It will decrease to a fixed value greater than zero.
   (C) It will decrease to zero.
   (D) It will remain the same.

8. The use of experimental design techniques early in the process development stage generally results in

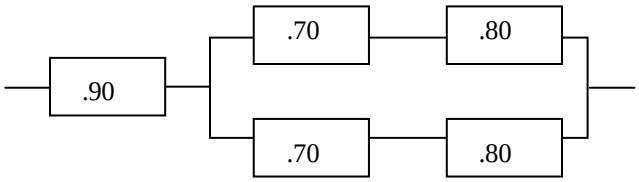
   (A) increased personnel and product costs
   (B) increased product development time
   (C) decreased variability around target requirements
   (D) decreased start-up process yields

SAMPLE EXAM

9. A qualification test is planned to establish whether a unit meets required minimum mean time between failures (MTBF). Which of the following tools can be used to estimate the chance that the unit will pass the test even if its true MTBF is below the required level?

   (A) Operating characteristic curve
   (B) Block diagram
   (C) Fault tree
   (D) Transition state matrix

10. The reliability block diagram of a system is shown in the following figure with component reliability noted in each block.



   What is the reliability of the system?

   (A) 0.670
   (B) 0.726
   (C) 0.804
   (D) 0.820

Questions 11-13 refer to the following information.

A reliability engineer needs to use an accelerated test plan to select a new material. The failure modes are known to be temperature-related.

11. Which of the following stress-related characteristics should be considered by the reliability engineer during the material selection stage?

   (A) Activation energy
   (B) Flexural energy
   (C) Tensile strength
   (D) Compression strength

12. Which of the following test techniques would allow the reliability engineer to evaluate the material quickly?

   (A) Ambient temperature test
   (B) Step-stress test
   (C) Full system test
   (D) Durability test

13. Which of the following approaches should be used for a field validation test of the new material?

   (A) Implement the material change and monitor field performance.
   (B) Field test a sample of only the new material in the system.
   (C) Field test samples of both old and new material in the system.
   (D) Run lab tests on two systems.

SAMPLE EXAM

14. Which of the following statements best describes the set of all values of a random variable?

(A) It is finite.
(B) It is an interval.
(C) It can be discrete or continuous.
(D) It can be tracked by using control charts or scatter plots.

15. Which of the following is the best description of randomization?

(A) A technique used to increase the precision of an experiment
(B) A means of assuring representative sampling
(C) The repetition of an observation or measurement
(D) The relationship between two or more variables

16. The hazard rate function for a device is given by

0.001 if $t \leq 10$ hours
and 0.010 if $t > 10$ hours

What is the reliability of this device at 12 hours?

(A) 0.970
(B) 0.980
(C) 0.988
(D) 0.990

17. Fault isolation is best facilitated by using

(A) trouble reports, corrective action reports, and inspection data
(B) interchangeability, redundancy, and corrective maintenance
(C) preventive maintenance, built-in test equipment, and design simplification
(D) periodic condition inspections and correction of detected deterioration

18. To be most cost-effective, a corrective action should be implemented between which of the following events?

	After	Before
(A)	Initial build	Final qualification test
(B)	Final qualification test	Initial production
(C)	Initial production	Field release
(D)	Field release	Field upgrades

19. In the model $y = 12.1x_1 + 5.3x_2 + \varepsilon$, the x_1 follows a Weibull distribution with a shape parameter of 3.5 and a characteristic life of 20; x_2 follows a lognormal distribution with a mean of 16 and a standard deviation (σ) of 2.5; and ε is a random variable with a mean of 0 and a σ of 1. In this situation, which of the following methods would be best to evaluate the distribution of y ?

(A) Regression analysis
(B) Monte Carlo simulation
(C) Analysis of variance
(D) Numerical integral

20. In design of experiments, the concept of "loss function" is related to

(A) Monte Carlo simulation
(B) Taguchi methods
(C) evolutionary methods
(D) regression analysis

21. A certain electronic component has a constant failure rate of 4×10^{-7}/hour. A system requires the use of 64 units of this component, and all of the components must function for the system to work. What is the system failure rate?

(A) 2.56×10^{-5}/hour
(B) 3.91×10^{-5}/hour
(C) 2.56×10^{4} hours
(D) 3.91×10^{4} hours

SAMPLE EXAM

22. When the order of items is not important, which of the following is the method to use to determine the number of sets and subsets of items?

(A) Combination
(B) Permutation
(C) Factorization
(D) Simulation

23. A system has four components in series with mean time between failures (MTBF) of 5,000, 6,000, 4,500 and 2,000 hours, respectively. What is the 200-hour system reliability?

(A) 0.804
(B) 0.832
(C) 0.898
(D) 0.989

24. One hundred units are subjected to a reliability test with duration 500 clock hours. During the test, 2 failures occur, at T_1 = 110 hours and at T_2 = 300 hours. The failed units are not replaced. On the basis of this sample, the one-sided 95% lower confidence limit of reliability of these units for a mission of 600 hours is

(A) 0.858
(B) 0.926
(C) 0.976
(D) 0.988

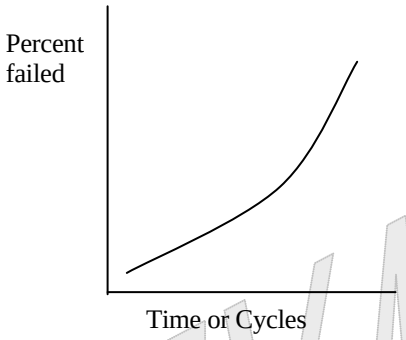
25. A fair coin is tossed 10 times. What are the expected mean and variance of the number of heads?

	Mean	Variance
(A)	0.5	0.025
(B)	5.0	2.500
(C)	5.0	5.000
(D)	10.0	5.000

26. Which of the following best offsets the implementation costs of a product safety program?

(A) Increased production quality
(B) Increased manufacturing safeguards
(C) Reduced regulatory requirements
(D) Reduced liability exposure

27.



Which of the following can be inferred from the Weibull analysis plot above?

(A) There is an initial period of time where no failures occur.
(B) The analysis includes censored data.
(C) More than one failure mechanism is included in the data.
(D) The hazard rate remains constant.

28. Which of the following must be known in order to establish a reliability specification?

(A) The usage environment
(B) The level of the system's quality
(C) The company's reliability policy
(D) The reliability model being used

SAMPLE EXAM

29. Which of the following probability distributions best satisfies the inequality $P(x < 0) > 0$?

(A) Two-parameter Weibull
(B) One-parameter exponential
(C) Normal
(D) Lognormal

30. Which of the following is considered the most valuable source of information on actual failure modes and mechanisms?

(A) Field data
(B) Qualification tests
(C) FMEAs
(D) User profiles

31. A component has strength with mean value of 9,000 N and standard deviation of 900 N. It has to withstand a load with mean value of 5,500 N and standard deviation of 800 N. Both strength and load are normally distributed. What is the probability of failure for the component?

(A) 2.0×10^{-5}
(B) 1.8×10^{-3}
(C) 5.8×10^{-3}
(D) 2.0×10^{-2}

32. Early in the concept phase of a new product development program, which of the following methods is most effective for incorporating desired product attributes into the design?

(A) Quality function deployment (QFD)
(B) Failure mode and effect analysis (FMEA)
(C) Fault-tree analysis (FTA)
(D) Failure reporting and corrective action systems (FRACAS)

33. Which of the following is the most appropriate measure of reliability?

(A) Manufacturing cost per unit
(B) Service cost per unit
(C) External customer satisfaction
(D) Internal customer satisfaction

34. A repair facility consists of two independent stations in a series. Repair times in hours follow normal distributions as shown below.

Station	Mean	Standard Deviation
1	20	3
2	10	2

What is the probability of completing a repair in 35 hours or less?

(A) 0.65
(B) 0.71
(C) 0.92
(D) 0.99

35. In a cross-functional team environment, the reliability function can influence product reliability primarily by

(A) integrating the reliability requirements into product design
(B) developing reliability tests
(C) performing thorough failure analysis
(D) monitoring the failure rates of various products

36. A Pareto analysis of field failure data indicates approximately equal magnitudes of the main failure modes. In this situation, the best next course of action is to look at

(A) the failure mode that is least expensive to investigate
(B) the failure mode that provides the highest return on investment if eliminated
(C) the failure mode that is closest to “no fault found”
(D) every possible contributor for each main failure mode

37. Which of the following types of data is best to estimate the life of a product?

(A) Time-to-failure
(B) Time-to-repair
(C) Failure modes
(D) Failure criticality

SAMPLE EXAM

38. Which of the following techniques is used to discover design flaws and implement fixes to affect all future manufactured units?

(A) Reliability growth modeling
(B) Reliability physics
(C) Markov modeling
(D) Monte Carlo simulation

39. Which of the following is the most appropriate way to improve product reliability during the design phase?

(A) Perform a worst-case analysis.
(B) Track manufacturing defects.
(C) Conduct supplier auditing.
(D) Increase the staff on the product development team.

40. The term "failure mode" is defined as the

(A) consequence of the mechanism through which a failure occurs
(B) physical, chemical, electrical, or thermal process that results in failure
(C) event or inoperable state in which an item or part of an item does not perform as specified
(D) failure caused by the failure of an associated item

41. Which of the following activities is most effective in increasing reliability during a product's lifecycle?

(A) Improving gage repeatability and reproducibility
(B) Developing an aggressive testing strategy
(C) Developing robust designs
(D) Developing capable processes

42. The following ANOVA table was completed from a full factorial experiment. The object of the experiment was to determine whether the impact of factors A, B, or their interaction (AXB) was significant at the 0.95 confidence level.

Source	df	SS
A	2	18.7
B	3	25.5
AXB	6	43.1
Error	24	65.3
Total	35	152.6

In this situation, which of the following is true?

(A) Only source A is significant.
(B) Only source B is significant.
(C) Only the interaction (AXB) is significant.
(D) All sources (A, B, and AXB) are significant.

43. In statistics, an estimation error that is persistent or systematic is called

(A) bias
(B) sensitivity
(C) random
(D) shift

44. Which of the following is designed to ensure that a structure has sufficient strength to operate in its service environment and under the loads specified?

(A) Stress-strength analysis
(B) Analysis of variance
(C) Destructive physical analysis
(D) Environmental stress characterization

SAMPLE EXAM

45. The influence of a failure mode and effects analysis (FMEA) on reliability is maximized at which of the following stages of development?

(A) Design
(B) Prototype
(C) Test
(D) Operation

46. The two-sample t-test used in hypothesis testing assumes that the two

(A) populations have the same mean
(B) populations are normally distributed
(C) samples are the same size
(D) samples are not randomly selected

47. Before sending a corrective action notice to a supplier, a manufacturer should review which of the following?

(A) The supplier's financial condition
(B) Its own manufacturing schedules
(C) Documented evidence of failures related to that supplier
(D) All procedures, processes, and training records related to that supplier

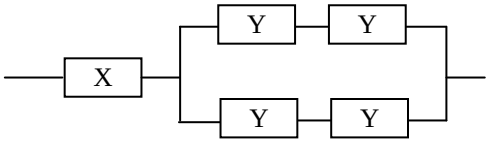
48. Which of the following information helps determine the value of a product's reliability to the customer?

(A) The failure rate and price of the product
(B) A Weibull analysis of product failure data
(C) An SPC analysis of product performance
(D) The effectiveness of corrective action on product failure

49. The most cost-effective product development phase in which to eliminate a hazard is

(A) design
(B) manufacturing
(C) burn-in
(D) field-failure analysis

50. A system consists of five units, as shown below.



The reliability of the X unit is 0.9900. The other four units are identical. If the system reliability goal is 0.9896, what is the minimum reliability that each of the Y units must have?

(A) 0.980
(B) 0.985
(C) 0.990
(D) 0.995

51. If final product and preproduction test data differ, which of the following types of data would be best for evaluating product reliability?

(A) Field use
(B) Accelerated test
(C) Monte Carlo modeling
(D) Force-field analysis

52. Which of the following is the most effective technique for prioritizing critical factors for problem-solving?

(A) Venn diagram
(B) Scatter diagram
(C) Pareto diagram
(D) Cause and effect diagram

SAMPLE EXAM

53. In reliability, the most common use of the Pareto principle is in determining

(A) whether the output of a process is stable
(B) whether problems in a system are sporadic or chronic
(C) what the defects are in a product or process
(D) what defects are responsible for the majority of the problems

54. Which of the following statements is true about the bathtub curve?

(A) The early phase represents wearout failures.
(B) The early phase shows increasing failure rate.
(C) The middle phase shows a decreasing failure rate.
(D) The middle phase represents random failures.

55. Which of the following practices represents the principle of preventive maintenance?

(A) Inspect periodically and repair or replace parts as necessary.
(B) When parts fail, replace with good ones.
(C) When parts fail, repair the failed parts.
(D) Replace all parts on a regularly scheduled basis.

56. Which of the following statements is true about reliability prediction?

(A) It is accurate in the determination of system failure causes.
(B) It contributes directly to system reliability.
(C) It forms decision criteria for selecting courses of action that affect reliability.
(D) It demonstrates that a proposed design will meet its reliability requirement.

57. A company is in a multi-product, competitive market. Which of the following is the most appropriate strategy to help capture the maximum market share?

(A) Reducing cycle time while introducing new, reliable products
(B) Increasing the reliability of current products
(C) Improving the capacity of manufacturing processes
(D) Performing aggressive field-testing

58. Accelerated life testing is most beneficial when performed on

(A) dead-on-arrival products
(B) products released to manufacturing
(C) products under development
(D) products returned from the field

59. A system has an availability of 95% when the MTBF is 500 hours and the mean time to repair is

(A) 22 hours
(B) 26 hours
(C) 133 hours
(D) 167 hours

60. The *x* and *y* axes of the bathtub curve are

	x	*y*
(A)	time	reliability
(B)	reliability	time
(C)	time	hazard rate
(D)	hazard rate	time

61. Which of the following is the most effective approach to minimize accidents caused by human error?

(A) Provide easy access to equipment.
(B) Provide clear user instructions to customers.
(C) Put automatic preventive features into the products.
(D) Put warning signs at the most visible locations.

SAMPLE EXAM

62. When parts are selected for a product in development, which of the following key elements should be considered first?

(A) Cost
(B) Serviceability
(C) Availability
(D) Application

63. A certain component has its strength distributed normally with an average of 20,000 pounds per square inch (psi) and a standard deviation of 1,200 psi. The stress on the component is also normally distributed with an average of 17,500 psi and a standard deviation of 800 psi. On the basis of this information, what is the component's reliability?

(A) 0.9052
(B) 0.9582
(C) 0.9814
(D) 0.9972

64. Correlation analysis is a technique used to measure the degree of

(A) statistical relationship between two random variables
(B) causal relationship between two random variables
(C) goodness of fit to normal distribution
(D) goodness of fit to exponential distribution

65. When the plot of the cumulative MTBF and the cumulative operating hours on log-log paper follows a straight line, the plot is known as

(A) a Weibull plot
(B) a normal plot
(C) a Duane plot
(D) an exponential plot

66. A fault tree analysis (FTA) differs from a failure mode and effects analysis (FMEA) in that an FTA

(A) starts by considering individual or combined lower-level failures first
(B) starts by considering system failure effects or top events first
(C) does not take into account human factors such as incorrect operation
(D) is typically used in conjunction with a cause and effect diagram

67. Which of the following statements is true about maintainability?

(A) It should be initiated during the logistics review.
(B) It should be initiated during the design stage.
(C) It is primarily a field service issue.
(D) It is primarily a contractual requirement.

68. Which of the following calculations is used to determine the overall tolerance for a serial combination of components?

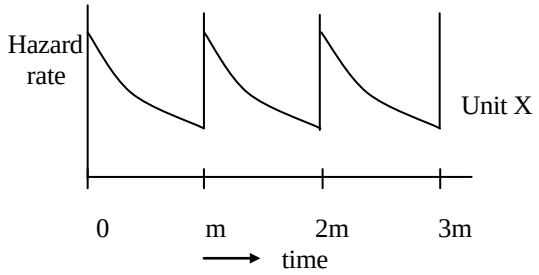
(A) The average of the tolerances
(B) The maximum of the tolerances
(C) The sum of the tolerances
(D) The square root of the sum of the squares of the tolerances

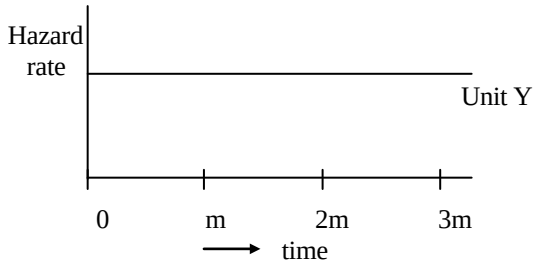
69. The primary objective of reliability-centered maintenance (RCM) is to

(A) obtain maintainability data
(B) preserve system function
(C) track maintenance training
(D) characterize the downtime distribution

SAMPLE EXAM

70. A system is comprised of units X and Y in parallel with hazard rates as shown below.





If "m" is the scheduled replacement interval, then replacement of unit

(A) X will increase failure probability of system
(B) X will decrease failure probability of system
(C) Y will increase failure probability of system
(D) Y will decrease failure probability of system

71. Typically, which of the following distributions is used to model equipment maintenance times?

(A) Lognormal
(B) Gamma
(C) Inverse beta
(D) Exponential

72. As a result of improper machining, a gear-tooth in a vehicle's transmission breaks causing the transmission to lock up and the vehicle to crash, injuring the driver. The failure mode in this case should be identified by the reliability engineer as the

(A) injured driver
(B) jammed transmission
(C) improper machining
(D) vehicle crash

73. An electromigration model for stress testing (MTTF = $AJ^{-n}e^{\frac{Ea}{KT}}$) is based on the

(A) stresses of voltage and vibration raised to powers
(B) Arrhenius temperature dependence and a constant
(C) current density to a power and the Arrhenius temperature dependence
(D) environmental stress screening and HALT testing

74. Which of the following is a model used for monitoring reliability growth?

(A) Duane
(B) Arrhenius
(C) Normal
(D) Lognormal

75. When reliability goals are being developed, reliability predictions are initially used to

(A) set goals for all portions of the life cycle of a system
(B) estimate potential performance of hardware and software with respect to reliability requirements
(C) measure customer needs and provide a means of defining quantitative reliability goals
(D) establish a competitive position with respect to reliability

SAMPLE EXAM

STOP.

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY GO BACK AND CHECK YOUR WORK ON THIS TEST.

APPENDIX A: Answer Sheet

For each sample test question, the correct answer is provided below along with the area of the body of knowledge (BOK) that the item is classified to. This sample examination is not intended to represent all areas of the BOK but to provide a sampling from each major topic area. All ASQ examinations are based on the BOK for that particular exam. To view the BOK for CRE, please go to http://www.asq.org/certification/reliability-engineer/bok.html

Question	BOK	Correct Answer
1	II.B.2	B
2	III.A.5	B
3	I.C.3	D
4	II.B.2	D
5	III.B.2	A
6	IV.B.1	A
7	VI.B.1	D
8	III.A.7	C
9	IV.B.2	A
10	IV.A.2	B
11	V.B.1	A
12	V.B.1	B
13	V.C.1	C
14	II.A.1	C
15	II.B.2	B
16	II.B.1	A
17	VI.B.4	C
18	VII.B.2	A
19	IV.A.3	B
20	III.A.7	B
21	IV.B.2	A
22	II.A.2	A
23	IV.A.2	A
24	II.B.2	B
25	II.A.3	B
26	I.C.3	D
27	VII.B.1	C
28	III.B.4	A
29	II.A.3	C
30	IV.A.1	A
31	III.A.2	B
32	I.A.7	A
33	I.A.2	C
34	VI.B.2	C
35	I.A.3	A
36	VII.B.2	B
37	VII.A.2	A
38	IV.A.3	A

Question	BOK	Correct Answer
39	I.A.1	A
40	III.A.3	A
41	I.B.4	C
42	III.A.7	D
43	II.A.1	A
44	III.A.2	A
45	III.A.3	A
46	II.B.3	B
47	VII.A.2	C
48	I.A.1	A
49	I.C.3	A
50	III.A.12	C
51	V.A.2	A
52	VII.B.1	C
53	VII.B.1	D
54	II.A.3	D
55	VI.B.1	A
56	IV.B.2	C
57	I.B.2	A
58	V.B.1	C
59	VI.A.3	B
60	II.A.3	C
61	III.A.10	C
62	III.B.1	D
63	III.A.2	B
64	II.A.1	A
65	V.B.3	C
66	III.A.5	B
67	VI.A.1	B
68	III.A.6	D
69	VI.A.2	B
70	VI.B.1	A
71	VI.B.2	A
72	III.A.3	B
73	V.B.1	C
74	V.B.3	A
75	IV.B.2	B

SAMPLE EXAM

APPENDIX B: Analyzing Body of Knowledge (BOK) Content

The following worksheet can be used to help you analyze the results of your answers on this sample examination. It can be used to determine which areas of the body of knowledge (BOK) you may want to study.

After learning which sample test questions you had correct, total the number you had correct and enter that number into the 2nd column of the worksheet. The 3rd column provides the total number of test questions that are in this sample examination for that major area of the BOK. The last column provides the total number of test questions that appear in a formal ASQ examination for that area of the BOK.

BOK Topic Area	Total You Had Correct on Sample Exam	Total in the Sample Exam	Total in Formal ASQ Exam
I. Reliability Management		10	***18***
II. Probability and Statistics for Reliability		14	***27***
III. Reliability in Design and Development		13	***26***
IV. Reliability Modeling and Predictions		10	***22***
V. Reliability Testing		9	***24***
VI. Maintainability and Availability		9	***15***
VII. Data Collection and Use		10	***18***
GRAND TOTAL		**75**	***150***

SAMPLE EXAM