Advanced Certification Study Guide

For Advancement to Certification Level 2

(Handbook 3-4.2)

3-4.2.1 – INTRODUCTION AND PROCEDURES

This is the Study Guide for the Level 2 Advanced Certification Exam. Like the exam, it has two parts, technical and safety. Out of the 108 questions and answers found in this Study Guide, only 50 questions will be on the exam; 25 questions from the technical portion and 25 questions from the safety portion.

The technical questions require definitions of common rocketry terms and ask for "rules-of thumb" that are known and used by experienced high-power enthusiasts. The safety portion comes from the Tripoli Unified Safety Code, which is available on the Tripoli website. Common rocketry definitions are included so that the language of rocketry can be used in the proper context with a few exceptions as noted below. Rules-of-thumb are used instead of detailed analyses to appeal to the greatest number of people.

TEST PROCEDURE

The Study guide is available to all Tripoli members regardless of their intent to certify, but a member must certify to Level 1 before taking the exam. The exam must be taken and passed ***before*** a Level 2 flight may be attempted.

CERTIFICATION AUTHORITIES

Within Tripoli, Certification Authorities are limited as follows: Prefects, Technical Advisor Panel members (TAPs), and the Tripoli Board of Directors (BOD). These individuals may certify members at the L1 and L2 level. Prefects may also temporarily authorize an L2 or higher certified member to serve as a Certification Authority at the L1 and L2 level. Only TAPs are authorized to certify members at the L3 level.

A member may take the exam from any qualified Certification Authority. A member wishing to certify must contact a Certification Authority to determine a convenient time and place for both parties involved. Certification Authorities should make themselves available by appointment, at launches, and at meetings where they can administer the exam.

Two versions of the exam are available; A and B. The Certification Authority can determine which exam to utilize prior to each exam.

WRITTEN AND ORAL EXAMS

The Advanced Certification exam may be taken in writing or orally.

PASS OR FAIL CRITERIA

A passing score of 90% is required. No more than 5 questions may be missed out of 50 total. The passing score shall be recorded on the universal certification form by the Certification Authority. The Certification Authority shall then destroy the passing answer sheet.

Members who fail the first exam can immediately take a second exam. If the member fails one exam, the Certification Authority shall utilize the opposite exam on the second attempt. If the member fails both exams, the member is not permitted to take the exam

again for a minimum of seven (7) days. The Certification Authority shall destroy failed exam answer sheets.

Once a member has passed the exam, they can complete the Level 2 certification process by making a successful Level 2 flight as outlined on the certification form within one year of the test date.

Members are not permitted to keep any copy of answers sheets for any reason.

EXPIRATION OF CERTIFICATIONS

Level 2 and Level 3 members are expected to be current on the knowledge necessary to serve in positions of responsibility within Tripoli, such as Range Safety Officers (RSO), Launch Directors (LDs), Launch Control Officer (LCO) or Prefects. Because a prolonged lapse in activity may lead to lost knowledge of current rules, a lapse of membership greater than two years will result in Level 2 and Level 3 members being required to pass the current L2 written test before being allowed to regain certification at those levels.

A lapse of membership longer than five years will result in a reset of certifications back to L0 for Tripoli members previously certified at any level.

LEGAL NOTICES

Tripoli appreciates the many volunteers who helped develop this test over time.

3-4.2.2 PART 1 – TECHNICAL QUESTIONS

1. Which of Newton's Laws best describes the behavior of a rocket motor?

a. Newton's First Law: A body continues in its state of rest or of uniform motion in a straight line unless it is compelled to change that state by forces impressed upon it

b. Newton's Second Law: The rate of change of momentum is proportional to the force impressed and is in the same direction as that force

c. Newton's Third Law: To every action there is always an equal and opposite reaction

2. How does Newton's Third Law "To every action there is always an equal and opposite reaction" relate to rocketry?

a. That the blast deflector must be strong enough to push the rocket off the launch pad at ignition.

b. That a rocket flies because the rocket motor "pushes" the rocket in a direction opposite of the exhaust jet.

c. That the thrust of a rocket motor is proportional to the air density at the launch site

3. What are the three forces acting upon a rocket during flight?

a. Thrust, rocket diameter and finish

b. Nose cone shape, thrust and drag

c. Gravity, thrust and aerodynamic drag

4. What are the three major factors that determine the maximum altitude of a high-power rocket in vertical flight?

a. Lift-off weight, propellant weight and motor thrust

b. Fin size, propellant weight and motor thrust

c. Motor thrust, rocket weight, and aerodynamic drag

5. For an inherently stable rocket, which statement about the center of gravity (CG) and the center of pressure (CP) is true?

a. The CG must be behind the CP relative to the desired direction of flight

b. The CG must be forward of the CP relative to the desired direction of flight

c. The CG must move forward (in the desired direction of flight) during the motor burn

6. A 4" diameter rocket with its motor is determined to have the center of gravity (CG) four inches behind the center of pressure (CP). Is this a rocket likely to be stable?

a. No, the CG should be at least two body diameters behind the CP

b. No, the CP must be behind the CG for the rocket to be stable

c. Yes, the CP is one body diameter in front of the CG

7. The center of pressure (CP) of a rocket is generally defined as:

a. The balance point of the rocket without the motor

b. The total area of the fins, airframe and nose cone divided by two

c. The point at which aerodynamic lift on a rocket is centered

8. What is the "rule-of-thumb" for a stable rocket?

a. That the center of gravity should be at least one body diameter in front of the center of pressure

b. That the center of gravity should be very nearly at the same point as the center of pressure

c. The rocket should balance near or at the center of gravity

9. You are at the launch site and decide to fly your rocket on a heavier motor than you simulated it on. Which statement regarding CG is true?

a. One can install the motor, recovery system and payload and determine the balance point of the rocket as it is ready for flight

b. One can balance the rocket with the motor hardware alone because that is the condition of the rocket after motor burnout

c. It is not necessary to test for the center of gravity when using a heavier motor because it has more thrust

10. What ordinarily happens to the center of gravity (CG) of a rocket during a solid rocket motor's thrusting phase?

a. The CG stays the same

b. The CG shifts forward

c. The CG shifts aft

11. How can a statically unstable rocket be made stable?

a. Using a heavier motor

b. Adding weight to the nose

c. Making the rocket shorter

12. What are three methods used to shift the center of gravity (CG) of a rocket forward?

a. Add weight to the nose, make the rocket longer, install larger fins

b. Add weight to the nose, make the rocket longer, use a smaller (or lighter) motor

c. Add weight to the nose, make the rocket shorter, use a smaller motor

13. What are three methods used to shift the center of pressure (CP) aft?

a. Make the rocket shorter, use larger fins, increase the number of fins

b. Make the rocket shorter, use smaller fins, add weight to the nose

c. Make the rocket shorter, change the number of fins, use a longer launch rod

14. The definition of coefficient of drag (C_d) is:

a. A dimensionless number that represents the effect of gravity and Mach number of the rocket

b. A dimensionless number dependent on the rocket configuration, Mach number and angle of attack

c. The force, in Newtons, exerted on the rocket by the atmosphere

15. What happens to the coefficient of drag (C_d) as the rocket approaches the speed of sound?

a. The C_d decreases

b. The C_d stays the same

c. The C_d increases.

16. For a subsonic rocket, what factors most greatly affect the coefficient of drag (C_d)?

a. Motor thrust, body diameter, nosecone shape and fin shape

b. Speed, airframe dimensions, nosecone shape and fin shape

c. Gravity, airframe dimensions, nosecone shape and fin shape

17. What effect does a boat tail have on a subsonic rocket's coefficient of drag (C_d)?

a. No effect, a boat tail is only a cosmetic design feature

b. It increases the C_d by changing the airflow over the fins

c. It decreases the C_d by reducing the base drag

18. The flight of a high-power rocket can be separated into three portions; they are:

a. Ignition, burnout and peak altitude

b. Powered flight, un-powered ascent and peak altitude

c. Powered flight, un-powered ascent and descent

19. Which describes the thrust curve of a regressive motor burn?

a. A high initial thrust relative to the ending thrust of the motor

b. A lower initial thrust relative to the ending thrust

c. The thrust curve is flat

20. Which describes the thrust curve of a progressive motor?

a. A general decrease in thrust during the burn

b. A general increase in thrust during the burn

c. About the same thrust at ignition as at burnout

21. A Bates grain has an essentially neutral thrust curve because:

a. Core burning motors always have a neutral thrust curve

b. The area of burning propellant remains relatively constant

c. The core is centered in the propellant grain

22. What is the most common function of a motor liner and the O-ring seals in a solid rocket motor?

a. To hold all the parts in place prior to ignition of the rocket motor

b. To make the motor easier to clean if it is a reloadable motor

c. To keep the hot gasses of the motor from burning or melting the motor case

23. What is the most common oxidizer in commercially available high power composite solid rocket motors?

a. Ammonium Perchlorate

b. Ammonium Nitrate

c. Ammonium Chlorate

24. What is NH_4ClO_4?

a. Ammonium Perchlorate

b. Ammonium Nitrate

c. Ammonium Chlorate

25. A small hole is typically drilled near the top of a high-power rocket's airframe, below the nosecone or payload section. Why?

a. This hole vents excessive ejection charge pressure, reducing shock cord stress

b. The hole permits on-board altimeters to obtain air pressure readings

c. The hole vents internal air pressure as the rocket gains altitude to prevent premature separation

26. How do you convert Newtons of thrust to pounds of thrust?

a. Add 4.45 to the number of Newtons

b. Multiply Newtons by 4.45

c. Divide Newtons by 4.45

27. What is a Newton?

a. 1 kg*m/s

b. 1 kg*m/s^2

c. 1 kg*m

28. What is the oxidizer most commonly used in a commercial hybrid rocket motor?

a. N_2O

b. N_2O_4

c. NO_2

29. **For a rocket with a much less than 10:1 "length to diameter" (L/D) ratio, such as spools and pyramids, what type of drag contributes significantly to stability and makes it possible to fly without much, if any, nose weight?**

    a. Nose drag

    b. Base drag

    c. Surface drag

30. **When doing an air-start of an L class motor, which of the following would be considered the safest configuration?**

    a. A single computer driving a single initiator

    b. Two computers each driving one initiator with a 0.5 second delay between firing the two initiators

    c. Two computers each driving one initiator with no delay between them

31. **A rocket with a motor cluster consisting of a central composite motor and four black powder motors, using five identical igniters:**

    a. Will result in all motors starting about the same time

    b. Will result in the composite motor starting first followed by the black powder motors

    c. Will result in the black powder motors starting first followed by the central composite motor

32. **What typically happens to a marginally stable rocket with a hybrid motor during the thrusting phase?**

    a. Nothing

    b. The rocket may become more stable

    c. The rocket may become less stable

33. **In general terms, the specific impulse of a rocket motor is:**

    a. The total thrust force of a motor throughout its action time

    b. The total impulse divided by a unit weight of propellant

    c. Inversely related to the diameter and length of the propellant grain

34. **In general terms, the total impulse of a rocket motor can be described as:**

    a. The product of the average motor thrust and burn time

    b. The product of the propellant weight and burn time

    c. The product of the propellant weight and the motor thrust

35. **The average thrust of a rocket motor is 100 Newtons, and the burn time is 4 seconds. What is the total impulse?**

    a. 25 Newton-seconds

    b. 400 Newton-seconds

c. 400 Newtons

36. Which of the motors listed below has the highest total impulse?

a. J200

b. J400

c. K200

37. Which of the motors listed below has the highest average thrust?

a. J200

b. J400

c. K200

38. What is the difference between a J640 and a J320 high power rocket motor (assume full 1280 Newton-second J motors)?

a. There is no difference between the motors, the numbers are manufacturer reference only

b. The J320 burns out twice as fast as the J640

c. The J640 burns out twice as fast as the J320

39. Which of the following has a total impulse (I_t) in the J motor range?

a. I_t = 600 Newton-seconds

b. I_t = 1000 Newton-seconds

c. I_t = 1290 Newton-seconds

40. What is a Newton?

a. The amount of force required to accelerate one pound one foot per second per second

b. The amount of force required to accelerate one kg one foot per second per second

c. The amount of force required to accelerate one kg one meter per second per second

41. What does the motor designation I220-8 mean?

a. The motor has between 320-640 N-s of impulse, an average thrust of 220 Newtons, with approximately 8 seconds between motor ignition and ejection

b. The motor has 220 N-s of impulse, an average thrust of 220 Newtons, with 8 seconds between motor burn-out and ejection

c. The motor has between 320-640 N-s of impulse, an average thrust of 220 Newtons, with approximately 8 seconds between motor burn-out and ejection

42. Rocket A is descending at 10 feet per second, rocket B weighs the same but is descending at 20 feet per second. Which statement is true?

a. The two rockets have the same kinetic energy

b. Rocket B has two times the kinetic energy of rocket A

c. Rocket B has four times the kinetic energy of rocket A

43. Rocket A weighs twice as much as rocket B. Both are descending at 20 feet per second. Which statement is true?

a. The two rockets have the same kinetic energy

b. Rocket A has two times the kinetic energy of rocket B

c. Rocket A has four times the kinetic energy of rocket B

44. What is the purpose of a launch rod, rail or tower?

a. To keep the rocket pointing in the right direction prior to flight

b. To control the rocket's flight long enough to allow aerodynamic stability

c. Both a. and b.

45. What is the purpose of a launch lug or rail buttons?

a. To add drag to the rocket at launch

b. To guide the rocket along the launch rod or rail

c. Both a. and b.

46. For a cluster rocket, which construction technique will minimize the effect of one motor failing to ignite?

a. Make the holes in the forward centering ring slightly closer to the rocket's centerline than those of the aft centering ring

b. Space the centering rings precisely one motor length apart

c. Use four smaller fins instead of three larger fins

47. What can happen if all the motors of a cluster do not ignite at launch?

a. Nothing, if the rocket is inherently stable

b. The rocket may not fly straight

c. The rocket will shred

48. What is a shred?

a. A failure of the rocket air frame during boost resulting in destruction of the rocket

b. A failure of the recovery system during boost

c. A failure of the motor causing early ejection

49. What is a Cato?

a. A failure of the rocket resulting in failure of the air frame during boost

b. A failure of the recovery system during boost

c. A failure of the motor causing flight termination

50. What is the primary requirement for a rocket motor ignitor?

a. It must transfer sufficient heat to the propellant to assure ignition

b. It must produce hot, high velocity gasses to assure ignition

c. It must have a high resistance to be reliable

51. Most APCP (ammonium perchlorate composite propellant) rocket motors are central-burning rather than end-burning:

a. Because most APCP has a specific impulse that is too low for end-burning motors

b. Because most APCP has a burn rate that is too low for useful end-burners

c. The premise is incorrect; most APCP motors ARE end-burners

52. Which of the following is most likely in dual-deployment rockets that use a drogue and a main parachute?

a. The drogue and the main can tangle if not properly arranged

b. The drogue slows the rocket too much and it drifts too far

c. The drogue does not slow the rocket enough and it lands hard

53. When using an accelerometer-based altimeter in a rocket that may exceed Mach 1:

a. A “Mach delay” must be built into the altimeter to avoid deployment of the recovery system at Mach

b. One or more access holes must be drilled in the electronics bay to permit access to the atmosphere during flight

c. Neither a. nor b. need be done

54. When using a pressure-sensor altimeter in a rocket that will not reach Mach 1:

a. One or more access holes must be drilled at the base of the nose cone to permit access to the atmosphere during flight

b. A timer, but *not* a motor delay, may be used as backup for deployment

c. One or more holes must be drilled in the electronics bay for atmospheric access

55. What is the major issue with accelerometer-based altimeters?

a. They are larger, and usually much more expensive, than pressure-sensor altimeters.

b. They do not have multiple capabilities such as dual deployment, ignition of air-starts, etc.

c. They may not deploy properly if the flight is significantly off-vertical

PART 1 – TECHNICAL QUESTION ANSWERS

#	Answer	Rationale / Comments
1	**c**.	Newton's Third Law. Applying a force in one direction always results in an equal force in the opposite direction.
2	**b**.	The rocket motor's thrust causes the rocket to accelerate in the direction opposite the motor's thrust. Thus, a rocket motor pushes only on the rocket, not on the air or launch pad.
3	**c**.	Gravity, thrust and drag are the forces acting on a rocket.
4	**c**.	The motor thrust, weight and aerodynamic drag are the primary forces considered when determining the altitude of a rocket. Please note that the weight of the rocket must consider the lift-off weight and the weight at burn-out to be complete.
5	**b**.	The center of pressure (CP) is where the aerodynamic lift, due to the rocket being at a non-zero angle of attack, is centered. For an aerodynamically stable rocket with the CP behind the center of gravity (CG), the lift which is centered aft of the CG will create a corrective moment to return the rocket to zero degrees angle of attack. Conversely, if the CP is ahead of the CG the lift will attempt to turn the rocket around so that the CP will again be behind the CG. This resultant "tumbling" is characteristic of an unstable rocket.
6	**b**.	The rocket is not stable because if the rocket rotated around its center of gravity (CG), the greater aerodynamic force forward of the CG would cause the rocket to rotate even farther, resulting in an unstable flight.
7	**c**.	The center of pressure (CP) is the point on the rocket where the aerodynamic lift is centered. This means that aerodynamic lift, if the rocket is at a non-zero angle of attack, forward of this point is balanced by the aerodynamic lift aft of that point.
8	**a**.	Keeping the center of gravity (CG) one body diameter in front of the center of pressure (CP) typically allows an adequate margin for rocket stability.
9	**a**.	Measuring the center of gravity (CG) by balancing the rocket requires that the rocket be prepared as though ready for flight. It is especially important to check when using a heavier motor than previously flown.
10	**b**.	As the propellant burns, the motor gets lighter causing the balance point or center of gravity (CG) to shift forward. This is why a marginally stable rocket may "act squirrelly" at launch, then stabilize and fly straight.
11	**b**.	Adding enough weight to the nose will shift the center of gravity (CG) forward of the center of pressure (CP).
12	**b**.	Moving the CG forward requires judicious design changes. The following are given as "rules of thumb": Adding weight forward of the existing CG shifts the CG further forward. Adding mass to the nose is one way to move the CG forward. Think of the rocket as a lever; making the rocket longer ahead of the CP is another way to shift the CG forward by making the lever longer. Using a smaller (or lighter) motor reduces the weight aft of the CG which also shifts the CG forward.
13	**a**.	Moving the CP aft requires judicious design changes. The following are given as "rules of thumb": Increasing the total fin area will move the CP aft. This can be accomplished by increasing the area on each fin and/or increasing the number of fins. The CP can also be shifted aft by making the rocket shorter ahead of the CP. This alone is generally not preferred because the CG is also shifted aft, and the CP/CG stability relationship may be compromised.
14	**b**.	The coefficient of drag (C_d) is a number that is used in equations for calculating the aerodynamic performance of a rocket. Values that determine the C_d are the rocket configuration (nose cone shape, airframe diameter(s), transition sections, fin size and shape, etc.), the rocket velocity as Mach number and the angle of attack.
15	**c**.	The coefficient of drag (C_d) increases and can be greater than 1 as the rocket exceeds Mach 1.
16	**b**.	As speed increases, the drag number changes. The length and diameter of the rocket factors into the total surface area. The nose cone shape affects the airflow over the front of the nose cone. The fin shape and fin area factor into the total surface area.

#	Answer	Rationale / Comments
17	**c**.	A boat tail reduces the drag for a subsonic rocket by reducing the base drag resulting from the discontinuity of the air flow as it leaves the end of the rocket.
18	**c**.	The three phases of flight of a high-power rocket are: (1) Powered flight – the period of time when the rocket motor is producing thrust against gravity and drag; (2) Un-powered ascent – the period of time after powered flight where the rocket's momentum allows the rocket to coast to peak altitude and is affected by gravity and drag; (3) Descent – the return of the rocket to Earth, which is affected by gravity and drag.
19	**a**.	As the regressive motor burns, the thrust decreases or regresses because the burning surface area of the propellant decreases. This is typical of slotted grains.
20	**b**.	As the progressive motor burns, the thrust increases or progresses because the burning surface area of the propellant increases. This is typical of core burning motors.
21	**b**.	As the motor burns from the core out, the ends of the grains also burn, making the grains shorter. This results in a relatively constant surface area and a flat or neutral thrust curve.
22	**c**.	The liner serves to keep the burning propellant (typically > 5000°F) from touching the motor case (aluminum melts at 1075°F) while the O-rings seal the ends to keep the hot gasses where they belong, that is going out of the nozzle.
23	**a**.	Ammonium Perchlorate is NH_4ClO_4 and is used in practically all modern solid rocket motors.
24	**a**.	NH_4ClO_4 is the chemical formula for Ammonium Perchlorate.
25	**c.**	Air pressure external to the rocket decreases as the rocket ascends. Trapped (higher) pressure within the rocket can prematurely separate the rocket. The hole vents this internal pressure to prevent separation. Note: The hole size is dependent on the size of the rocket and volume of air to be vented; larger airframes require larger or more holes. Use caution in locating the hole so the nose cone or payload coupler does not block air flow through the hole. Be sure to position the hole such that ejection charge pressure is not vented before recovery system deployment.
26	**c**.	Divide by 4.45
27	**b**.	kg*m/s^2
28	**a**.	N_2O or nitrous oxide, also called NOX.
29	**b**.	Base drag. In a three-part article in Apogee Rocketry's Peak of Flight (issues 154, 158, and 162), Bruce Levison explained how base drag effectively shifts the dynamic CP rearward for short wide rockets including spools, pyramids, and short squat rockets like the Estes Fat Boy. This dynamic CP (meaning the effective CP while the rocket is in flight) allows such rockets to fly without adding nose weight. https://www.apogeerockets.com/Peak-of-Flight?pof_list=archives&m=education
30	**a**.	A single computer driving a single initiator.
31	**c**.	Black powder motors do not have a significant startup time and will ignite as soon as the flame front is encountered. Ammonium Perchlorate-based composite motors require heat and pressure to start the combustion process and generally require at least a half-second before ignition occurs.
32	**c**.	As the CG of the hybrid motor shifts aft, so does the CG of the rocket, which may result in an unstable flight.
33	**b**.	Specific impulse is a term used to define the efficiency of a rocket propellant and is the total impulse derived from a unit weight of propellant.
34	**a**.	Total impulse is the amount of thrust produced by a motor over its action time. For instance, a motor may produce 10 pounds of thrust for 4 seconds resulting in a total impulse of 40 pound-seconds.
35	**b**.	Multiply the average thrust (100 Newtons) by the burn time (4 seconds) to get the total impulse of 400 Newton-seconds.
36	**c**.	The J motor has a range of 641 to 1280 Newton-seconds, and the K motor has a total impulse range of 1281 to 2560 Newton-seconds.
37	**b**.	Even though the total impulse of the K motor is greater than the J motor, the J motor's average thrust is 400 Newtons versus the K motor's 200 Newtons.

#	Answer	Rationale / Comments
38	**c**.	The burn time is determined by dividing the total impulse (J = 1280) by the average thrust of each motor. The burn time for the J640 is: 1280 Newton-seconds ÷ 640 = 2 seconds, and for the J320 is: 1280 Newton-seconds ÷ 320 Newtons = 4 seconds.
39	**b**.	A J motor is in the range of 640.01 to 1280 Newton-seconds. Therefore, a 1000 Newton-second motor is a midrange J. The 600 Newton-second motor is an I motor, and the 1290 Newton-second motor is a K motor.
40	**c**.	The Newton is an international (metric) unit of force and is the force required to accelerate one kilogram (2.2 lbs.) one meter (39.4 inches) per second per second.
41	**c**.	This is an I motor with a total impulse range of 320.01 to 640 Newton-seconds, an average thrust of 220 Newtons and an ejection delay of 8 seconds after burn-out.
42	**c**.	Kinetic energy (K_e) - energy of motion - is calculated using the equation $\mathbf{K_e = ½mv^2}$. Because velocity is squared, when two objects have the same mass, one moving twice as fast has 2^2 or 4 times as much kinetic energy as the slower one.
43	**b**.	Kinetic energy (K_e) - energy of motion - is calculated using the equation $\mathbf{K_e = ½mv^2}$. Thus, kinetic energy is directly proportional to mass; doubling the mass will give twice the kinetic energy
44	**c**.	The launch rod, rail or tower has a dual purpose. It is pointed in a direction to govern the rocket's trajectory to a degree, and it guides the rocket at the beginning of its flight to allow it to gain sufficient velocity for a stable flight. Stable flight is achieved when the air flowing over the rocket and its fins allows the rocket to correct its flight by forcing rotation around the rocket's center of gravity.
45	**b**.	The launch lug or rail buttons attach the rocket to the launch rod or rail allowing the rocket to be guided by the rod or rail at launch.
46	**a**.	If the axis of the motor passes through or very near the center of gravity, the effect of unbalanced thrust is usually reduced. This can be accomplished by bringing the forward end of each motor closer to the axis of the rocket.
47	**b**.	Not having ignition of all clustered motors results in the thrust being asymmetrical. This unbalanced thrust may force the rocket to fly in an arc that will not achieve a vertical flight.
48	**a**.	A shred happens when the rocket is improperly built or has a rocket motor that is too powerful for that particular rocket. In a typical shred sequence, the velocity of the rocket has increased to a point where airframe, fins or other structural parts cannot take the loads. When one or more of those part fail, it typically causes the rocket to become unstable resulting in the rapid destruction of the rocket.
49	**c.**	A Cato is short for catastrophic motor failure. This occurs when the nozzle, forward bulkhead or casing fails. The immediate result is abrupt termination of thrust which results in the rocket failing.
50	**a**.	A motor ignitor must deliver sufficient heat to the propellant to ignite it. This may be in the form of hot gas, hot burning particles, a hot wire, or a combination of all three.
51	**b**.	APCP has about three times the specific impulse of black powder. But most APCP burns slowly and must have a large burning surface area as in a Bates grain or other core-burning configuration to generate enough hot gases for flight.
52	**a**.	The drogue and main parachute usually must be arranged to eject from separate sections of the rocket to minimize the possibility of tangling. In some cases, a drogue is not used at all, to avoid the problem.
53	**c**.	Accelerometers measure acceleration internally, entirely within the accelerometer chip. Access to the atmosphere is not required, and air pressure changes such as the pressure pulse of passing Mach 1 does not affect the accelerometer chip.
54	**c**.	A pressure-sensor altimeter does require access to the atmosphere, so the electronics bay must be vented.
55	**c**.	Accelerometers can be quite small, need not be expensive, and can have the same multiple capabilities as pressure-sensor altimeters. But the electronics of an accelerometer assume a nearly vertical light, so that a flight that deviates significantly from vertical may have problems.

3-4.2.3 PART 2 – SAFETY CODE QUESTIONS

1. **What is the purpose of the Tripoli Unified Safety Code?**
   a. Establish guidelines for reasonably safe operation of rockets at a Tripoli launch
   b. Establish guidelines for building of rockets at a Tripoli launch
   c. Establish guidelines for the building of motors at a Tripoli launch

2. **Although Tripoli launches involve several layers of safety rules intended to increase safety, _____ is ultimately responsible for the rocket and flight?**
   a. The Range safety officer
   b. The launch Director
   c. The flier

3. **The flier shall document the location of the center of ____ and be able to demonstrate the center of _____? (Answer in order of blanks)**
   a. Gravity, Pressure
   b. Pressure, Gravity
   c. Pressure, Thrust

4. **Which of the following motor types are not allowed to be made and flown by a Level 2 flier as a research motor?**
   a. Research Black Powder Motor
   b. Liquid rocket motors (except nitrous oxide hybrids)
   c. Both a. and b.

5. **Rockets flown at Tripoli launches may carry:**
   a. Vertebrate Animals
   b. Hazardous payloads including those which are poisonous, flammable, incendiary, or explosive
   c. Neither a. nor b.

6. **What is the Authority Having Jurisdiction (AHJ)?**
   a. The organization, office or individual responsible for enforcing requirements of a code or standard, or for approving equipment, materials, an installation or a procedure
   b. A court proceeding that rule on high power rocketry activities
   c. The individual preparing a high-power rocket for flight

7. **What is a complex high-power rocket?**
   a. A rocket having more than one stage
   b. A rocket having a cluster of rocket motors
   c. Either a. or b.

8. What are the minimum criteria that define a high-power rocket?

a. A rocket with a single motor with more than 160 Newton-seconds total impulse or an installed impulse of 320 Newton-seconds and no more than 40,960 Newton-seconds

b. A rocket with a single motor having an average thrust in excess of 80 Newtons or any sparky rocket motor (usually using titanium pieces)

c. Either a. or b.

9. What is the maximum weight of a model rocket with motors installed?

a. 53 oz. (1500 g)

b. 1 lb. (453.6 g)

c. There is no maximum weight limit to a model rocket

10. When is an active recovery device not necessary in a high-power rocket?

a. When the high-power rocket is intended for ballistic flight

b. When the rocket has a bursting charge

c. When the rocket employs a passive recovery system (e.g.: tumble recovery, aero-braking)

11. Range activity shall cease whenever a thunderstorm has been detected within ____ miles (kilometers) of the launch site?

a. 5 (8 kilometers)

b. 10 (16 kilometers)

c. 20 (32 kilometers)

12. At what total impulse and/or average thrust does a motor become high power?

a. A rocket motor with more than 80 Newton-seconds of total impulse and 80 Newtons average thrust

b. A rocket motor with more than 160 Newton-seconds of total impulse or 80 Newtons average thrust

c. A rocket motor with more than 160 Newton-seconds of total impulse and 160 Newtons average thrust

13. While a 3:1 average thrust to weight ratio is the absolute minimum established in the Tripoli Unified Safety Code, what is the typical initial minimum thrust to weight ratio for a rocket?

a. 4:1

b. 5:1

c. 12:1

14. Who may operate a high-power rocket?

a. Any member of a nationally recognized rocketry organization

b. Only those licensed by the federal government

c. A certified user as defined in the Tripoli Unified Safety Code

15. What operating clearances must be complied with for flying high power rockets?

a. The Tripoli Unified Safety Code

b. The Tripoli Unified Safety Code, Regulations controlling airspace for country of launch and any other applicable federal, state and local regulations

c. NFPA and the FAA

16. What criteria apply to the construction of a high-power rocket?

a. Use suitable materials to withstand operating stresses and retain structural integrity in flight

b. Use only the lightest weight materials for the construction of high-power rockets

c. Use materials that allow minimal flex of the rocket in flight

17. When must the stability of a rocket be determined?

a. If the safety monitor requests it

b. During the design of the rocket

c. When the rocket is prepared for flight

18. Who can override an RSO decision pertaining to safety?

a. RSO decisions pertaining to safety are final and may not be overridden by any other range personnel including the launch director

b. The Launch Director

c. A Tripoli BOD member, prefect, or TAP

19. When is it permissible to catch a high-power rocket?

a. If the rocket weighs less than 2.2 pounds or 1 kg

b. It is never permissible to catch a high-power rocket

c. If the rocket is falling slowly enough that it is deemed not to be a hazard

20. Except for pertaining to safety, who may override a launch directors' decision?

a. The LCO

b. A Tripoli BOD member, prefect or TAP

c. Except for pertaining to safety, the launch director's decision is final and cannot be overridden

21. When must a high power rocket launching device incorporate a blast deflector?

a. When necessary to prevent damage or reduce risk of fire

b. All launch systems must incorporate a blast deflector

c. When the design of the launch device requires it

22. What is the maximum launch angle from vertical for a high-power rocket?

a. 30º

b. 20º

c. There is no maximum launch angle

23. What are the elements of an ignition system?

a. Wireless controlled, electrically operated, a launch switch that returns to OFF when released

b. Wireless controlled, electrically operated and a removable safety interlock in series with the launch switch

c. Includes an arming switch with a removable key or interlock, which disables the entire launch control system when removed and uses a momentary switch to command the rocket motor ignition

24. When shall the motor ignitor(s) be installed in a high-power rocket motor?

a. At the launcher or a designated prep area

b. When the motor is installed in the rocket

c. Neither a. nor b.

25. When may the physical disconnects that inhibit energetics be connected to power?

a. In the flier Prep area

b. At the pad or other designated range area as indicated by the launch director

c. Both a. and b.

26. What is a class 1 rocket?

a. A model rocket with a G motor or smaller

b. A model rocket with more than 125 g (4.4 oz.) of propellant and more than 1500 g (53 oz.) pad weight

c. A model rocket with 125 g (4.4 oz.) or less of propellant and 1500 g (53 oz.) or less pad weight

27. What is the launch site criteria?

a. No less than one-quarter the maximum altitude expected or granted by the FAA

b. No less than 1500 feet (457 m)

c. Both a. and b.

28. What is the minimum distance from a launch site to any person or property not associated with the operation?

a. 1000 feet (305 m)

b. 1500 feet (457 m)

c. No minimum distance if the building occupants are informed of the activity.

29. How close can spectators be to a high-power rocket launch?

a. At the distance defined by the Safe Distances Table

b. Half the distance defined in the Safe Distance Table

c. Double the distance defined in the Safe Distance Table

30. What is the maximum altitude allowed for flying high power rockets if there is a cloud ceiling of 3,000 feet (914 m) and an FAA waiver to 15,000 feet (4572 m)?

a. Up to 15,000 feet (4572 m)

b. Up to 3,500 feet (1067 m)

c. Up to 3,000 feet (914 m)

31. What is the limit of surface wind for launching a high-power rocket?

a. 30 MPH (48 km/h)

b. 20 MPH (32km/h)

c. 15 MPH (24km/h)

32. When may a high-power rocket be launched?

a. After warning the spectators and after giving a 5 second countdown

b. When all systems are ready and after giving a 5 second countdown

c. After announcing the rocket and after giving a 5 second countdown

33. What is a class 2 rocket?

a. A rocket other than a model rocket propelled by motors with greater than a combined total impulse of 640 N-s (143.9 lb-s)

b. A rocket other than a model rocket propelled by motors with greater than a combined total impulse of 40960 N-s (9208 lb-s)

c. A rocket other than a model rocket propelled by motors with less than a combined total impulse of 40960 N-s (9208 lb-s)

34. What is the minimum distance for smoking (or open flames) from high power rocket motors, motor reloading kits and pyrotechnic modules?

a. 10 feet (3m)

b. 25 feet (8m)

c. There is no minimum distance

35. When are you allowed to install an igniter or head end ignition module into any motor including a multistage, cluster or air start type rocket?

a. In the flier prep area

b. At the RSO table

c. At the pad or other designated area as established by the launch director

36. An R/C Rocket Boosted Glider (RBG) may be launched in which direction in regard to the flightline?

a. Parallel to or away from

b. Parallel to or towards

c. There is no direction requirement

37. At what impulse does a class 3 rocket start?

a. Above 5120 N-s (1151 lb-s)

b. Below 40960 N-s (9208 lb-s)

c. Above 40960 N-s (9208 lb-s)

38. Test flights or first flights of R/C RBG shall be launched from the distance specified by the total installed impulse in the Safe Distance Table plus _____ Ft?

a. 0

b. 50

c. 100

39. What is the maximum angle (in degrees) from vertical a model rocket can be launched from?

a. 30

b. 20

c. 10

40. The minimum safe distance to any spectator when a model rocket is launched shall be_____Ft?

a. 30

b. 50

c. 100

41. The minimum distance for all involved rockets shall be the complex distance for the total installed impulse of the motors in all rockets when _____ or more rockets are launched simultaneously?

a. 1

b. 2

c. 3

42. When can steel nozzles be used in research motors?

a. When the nozzle throat is recessed within the case of a sugar motor

b. On any research motor

c. Never

43. What is the age limit Tripoli recognizes for a certified solid propellant high power rocket motor user?

a. 21 years of age

b. 18 years of age

c. There is no age limit

44. What is the minimum safe distance for a non-complex H, I or J motor?

a. 50 ft (15m)

b. 100 ft (30m)

c. 200 ft (61m)

45. When may Research Motors that have been sold for a profit be used at a Tripoli Launch?

a. When the motors are not transported outside the state of manufacture

b. When the sale of motors is limited to certified users

c. It is never permitted

46. Which of the following materials can be used for research motor cases?

a. Metallic cases made of non-ferrous ductile metals such as 6061 aluminum alloy

b. Metallic cases made of ferrous metals such as Steel

c. Non-metallic cases made of PVC

47. When is it permissible to consume alcohol when prepping or launching high power rockets?

a. When the preparation is done the day before the launch

b. If the blood alcohol level is below the “impaired” level

c. It is never permitted

48. Organizations that may certify high power rocket motors include:

a. Tripoli Rocketry Association (TRA) and the National Association of Rocketry (NAR) only

b. The Bureau of Alcohol, Tobacco, Firearms, and Explosives (BATFE)

c. TRA, NAR, and the Canadian Association of Rocketry (CAR)

49. When can electronics that control energetics be powered on?

a. Before closing the rocket ebay in your campsite

b. After you have been through the rocket inspection

c. After the rocket is vertical on the pad but before the motor igniter is installed

50. The maximum landing speed of a rocket is not to exceed____?

a. 50 ft/s (15 m/s)

b. 35 ft/s (11 m/s)

b. 15 ft/s (4 m/s)

51. Who in Tripoli may certify a member Level 1 or Level 2?

a. The prefect

b. A TAP member

c. A member of the Tripoli Board of Directors, the prefect, or a TAP member

52. Who is allowed in the high-power launch area at a Tripoli launch?

a. Any invited person

b. Spectators

c. Tripoli TMP or Jr L1 NAR Members and any Tripoli or NAR member 18 years old or older

53. When is electronically actuated recovery necessary?

a. There is no requirement, it is up to the flier

b. A high-powered rocket launched with an installed impulse greater than 2560 N-sec

c. A high-powered rocket launched with an installed impulse greater than 5120 N-sec

PART 2 – SAFETY CODE ANSWERS

All code sections are from the Tripoli Unified Safety Code unless otherwise stated.

#	Answer	Safety Code Section(s) / Comments
1	**a.**	1-2.1
2	**c.**	7-1
3	**b.**	7-1.2
4	**c.**	10-8
5	**c.**	7-9
6	**a.**	15 – Definition of AHJ
7	**c.**	15 – Definition of Complex Rocket
8	**c.**	15 – Definition of High Power Rocket/Motor
9	**a.**	15 – Definition of Model Rocket
10	**c.**	11-2
11	**b.**	7-10
12	**b.**	15 – Definition of High-Power Rocket Motor
13	**b.**	7-1.4
14	**c.**	15 – Definition of High-Power Rocket Flier (HPR Flier)
15	**b.**	3-1(1.1,1.2,1.3)
16	**a.**	7-1.1
17	**c.**	7-1.2
18	**a.**	8-3
19	**b.**	11-5
20	**c.**	8-4
21	**a.**	7-5
22	**b.**	13-6
23	**c.**	7-7.1,7.2
24	**a.**	13-7
25	**b.**	13-8
26	**c.**	15 – Definition of Model Rocket
27	**c.**	13-16.1
28	**b.**	13-16.1
29	**a.**	13-17 Safe Distance Table
30	**c.**	9-6
31	**b.**	9-3
32	**c.**	9-1, 9-2

#	Answer	Safety Code Section(s) / Comments
33	**c.**	15 – Definition of High Power Rocket
34	**b.**	13-14.1
35	**c.**	13-7
36	**a.**	14-3.8
37	**c.**	15 – Definition of Class 3 Rocket
38	**c.**	14-3.3
39	**a.**	12-1
40	**b.**	12-4
41	**c.**	13-13.1
42	**a.**	10-10.5
43	**b.**	15 – Definition of Adult flier, High Power Rocket Flier
44	**b.**	13-17 Safe Distance Table
45	**c.**	10-6
46	**a.**	10-10
47	**c.**	7-12
48	**c.**	Currently the only motor testing authorities which reciprocally recognize each other are NAR S&T, CAR MCC, and Tripoli TMT. 15 – Definition of Certified Motor.
49	**c.**	7-8, 13-8, and 13-9
50	**b.**	11-1
51	**c.**	Certification Rules, summarized in this Study Guide and explicitly described within the certification procedures on the Tripoli website: www.tripoli.org/certification
52	**c.**	6-All
53	**b.**	11-6