Perth Advanced Rocketry Club Inc (PARC)

High Power Rocketry Certification Procedures

prepared by PARC COMMITEE

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INTRODUCTION

This study guide is available to all “Perth Advanced Rocketry Club” (PARC) members on request. A small fee is charged to cover printing and binding costs, or the document can be downloaded free from the following web site :

http://www.triaxproducts.com.au/parc/

Adults (18+) without being a member of a rocket club are able to purchase black powder rocket engines from a hobby shop with a total impulse not exceeding 20Ns (ie.. typically Estes “A” to “D” engines). To gain access to rocket engines with a total impulse greater than 20Ns (ie. composite Aerotech single-use or re-loadable engines) a person must join a rocket club and complete an application for the issue of a “Pyrotechnics Operators Permit” (POP) governed by the Western Australian “Department of Consumer and Employment Protection (Resources Safety)” (DOCEP). A $17.50 fee for the POP is payable to DOCEP.

PARC INC CERTIFICATION LEVELS

The following table details the levels available to PARC Members:

Level	Pre-requisites	Flight Test/Exam	Motors Allowed
a	NIL	NIL	A to D (Black Powder) 2.5Ns - 20Ns
b	Membership of PARC Inc	Successful Application for POP.	D to G (Composite) 20Ns - 160Ns
1	POP Permit	Level 1 Exam Fly a H powered rocket successfully.	H (HPR) 160Ns - 320Ns
1a	POP Permit passed level 1 powered rocket flight test & exam	Fly a I powered rocket successfully.	I (HPR) 320Ns - 640Ns
2	Passed Level 2 Certification Exam. Passed Level 1a powered rocket flight test.	Level 2 Exam. Fly a J or K powered rocket successfully.	J & K 640Ns - 2560Ns
3	Passed Level 2 powered rocket flight test. Completed Level 3 project.	Fly an L powered rocket successfully.	Open

MINIMUM REQUIREMENTS FOR HPR CERTIFICATION

1. A person seeking HPR Certification must be over 18 years of age. A current Drivers License, Passport, or Birth Certificate are acceptable to use as proof of age.

2. The individual must be a member in good standing with the Perth Advanced Rocketry Club Inc (PARC) at the time of certification. Current PARC membership card and your current POP permit will be required prior to the certification attempt.

3. Motors used for certification attempts must be currently certified by a national organization (e.g., NAR, Tripoli, CAR) with a recognized certification program.

LEVEL 1 CERTIFICATION

"H" IMPILSE (160.01-320.00 Ns)

- The modeler must demonstrate their ability to build and fly a rocket containing a H impulse class motor.
- Single use or reloadable technology motors are permitted (no hybrids).
- The modeler must assemble the reloadable motor, if used, in the presence of a certification official.
- Certification at this level permits rocket flights with motor(s) having a maximum total impulse of 320 Newton seconds.

LEVEL 1a CERTIFICATION

"I" IMPULSE (320.01-640.00 Ns)

- The modeler must demonstrate their ability to build and fly a rocket containing a I impulse class motor.
- Single use or reloadable technology motors are permitted (no hybrids).
- The modeler must assemble the reloadable motor, if used, in the presence of a certification official.
- A successful “H” impulse Flight Test must have been performed.
- Certification at this level permits rocket flights with motors having a maximum total impulse of 640.00 Newton seconds.

LEVEL 2 CERTIFICATION

"J" & "K" IMPULSE (640.01-2560.00 NS)

- The modeler must demonstrate their ability to build and fly a rocket containing a J or K impulse class motor.
- Single use, reloadable or hybrid technology motors are permitted.
- The modeler must assemble the reloadable or hybrid motor, if used, in the presence of a FTO.
- Certification at this level rocket flights with motors having a maximum total impulse of 2560 Newton seconds.

LEVEL 3 CERTIFICATION

"L+" IMPULSE (2,560.01-40,960.00 NS)

- The modeler must demonstrate their ability to build and fly a rocket containing an L impulse class motor.
- Single use, reloadable or hybrid technology motors are permitted.
- The modeler must assemble the reloadable or hybrid motor, if used, in the presence of a FTO.
- Certification at this level rocket flights with motors having a maximum total impulse of 40,960NS Newton seconds.

IMPORTANT - A ONE YEAR LAPSE IN MEMBERSHIP VOIDS CERTIFICATION AT ANY AND ALL LEVELS.

FLIGHT TEST OFFICER (FTO)

Only current PARC members who themselves are certified to the same level as the certification level required and have passed the Level 1 written exam are qualified to administer the flight test. It is the responsibility of the member requiring certification to contact an FTO to confirm their availability at a PARC launch to conduct the flight test.. Members should be understanding and patient with scheduling. PARC FTO's should especially make themselves available at launches to conduct the flight test. A list with contact details is provided upon joining the club, and an updated list of all PARC FTO's will be published on the Official PARC website.

HPR FLIGHT TEST PROCEDURE (All Levels)

1. A flight test may be attempted at any PARC Inc launch that an FTO is available.
2. Relevant CASA regulations requiring notification or waivers must be complied with.
3. The individual attempting certification must complete a PARC High Power Certification Application prior to their certification attempt, and have a current POP (Pyrotechnic Operators Permit) and pass the exam for level being attempted.
4. If certification to a level other than Level 1-H is desired, the individual must provide proof of previous certification(s).
5. The model will be subjected to a safety inspection prior to flight. The safety inspection form is on the back of the PARC High Power Certification Application.
6. During the safety inspection the modeler will be expected to answer oral technical questions related to the safety and construction of their model.
   The questions may include (but not limited to) identification of the model's center of gravity and center of pressure, methods used to determine model stability, and interpretation of the rocket motor's designation. The certification officials will check the appropriate blocks in the "pre-flight" section of the High Power Certification Application form.
7. The individual will fly their model.
8. The FTO must witness the flight.
9. Stability, deployment of the recovery system, and safe recovery should be considered when evaluating safety of the flight.
10. Models experiencing a catastrophic failure of either the airframe, rocket motor and/or recovery system (e.g. shock cord separation) will not be considered as having a safe flight.
11. The model must be returned to the certification officials after flight. and be inspected to verify engine retention and for evidence of flight-induced damage.
12. The certification team will complete the relevant section of the High Power Certification Application form indicating that a safe flight was made and that the post-flight inspection was satisfactory.
13. If the flight is successful, the FTO will sign the certification application and forward the document along with the members membership card to the Club Secretary for processing. The new membership card will be returned within one (1) week with the Official PARC Certification Stamp for the level attempted. DOCEP will be notified by writing that the member is now certified to the new level.

LEVEL 1 CERTIFICATION EXAM

The Level 1 certification exam is made up of ten (10) "Technical" questions and ten (10) "Safety Code" questions. This was designed to be a written exam. However, we have made exceptions for those who cannot read or are not able to make an exam venue (particularly country or interstate members). If this is the case, the member should contact a committee delegate to organize an oral examination by telephone.

EXAM ADMINISTRATOR

An FTO may administer the Level 1 written exam. It is the responsibility of the member requiring certification to contact an FTO to determine a convenient time for both to take the exam. Members should be understanding and patient with scheduling. Committee members should especially make themselves available by appointment, at launches or at meetings to administer the exam.

PASS OR FAIL

A passing score is 90%, no more than 2 missed questions out of 20. Upon successful completion of the Level 1 Certification Exam, the FTO will forward the completed exam document along with the members' membership card to the Club Secretary for processing. The membership card will be returned within one (1) week with the Official PARC Stamp.

Members shall not be permitted to keep a copy of the answer sheet for any reason. Members who fail an exam shall go back and study this material. The member shall not be allowed to re-take the exam for a minimum of seven (7) days. The Exam administrator shall destroy all failed exams. Under no circumstances shall failed exams be kept on file by the FTO or by the PARC Secretary.

LEVEL 2 CERTIFICATION EXAM

The Level 2 certification exam is made up of twenty (20) "Technical" questions and ten (10) "Safety Code" questions. This was designed to be a written exam. However, we have made exceptions for those who cannot read or are not able to make an exam venue (particularly country or interstate members). If this is the case, the member should contact a committee delegate to organize an oral examination by telephone.

EXAM ADMINISTRATOR

An FTO may administer the Level 2 written exam. It is the responsibility of the member requiring certification to contact an FTO to determine a convenient time for both to take the exam. Members should be understanding and patient with scheduling. Committee members should especially make themselves available by appointment, at launches or at meetings to administer the exam.

PASS OR FAIL

A passing score is 90%, no more than 3 missed questions out of 30. Upon successful completion of the Level 2 Certification Exam, the FTO will forward the completed exam document along with the members' membership card to the Club Secretary for processing. The membership card will be returned within one (1) week with the Official PARC Stamp.
Members shall not be permitted to keep a copy of the answer sheet for any reason. Members who fail an exam shall go back and study this material. The member shall not be allowed to re-take the exam for a minimum of seven (7) days. The Exam administrator shall destroy all failed exams. Under no circumstances shall failed exams be kept on file by the FTO or by the PARC Secretary.

LEVEL 1 CERTIFICATION QUESTIONS

PART A (Technical Questions)

1. What is NH_4ClO_4?
    a. Ammonium Perchlorate.
    b. Ammonium Nitrate.
    c. Ammonium Chlorate.

2. Which of Newton's Laws best describes the behavior of a rocket motor?
    a. Newton's First Law: Every 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 of that force.
    c. Newton's Third Law: To every action there is always an equal and opposite reaction.

3. What does the "H" in the motor designation H100-5 stand for?
    a. It is the first letter in the manufacturer's name.
    b. It indicates the total power range or impulse range of the rocket motor.
    c. It indicates the total thrust of the rocket motor.

4. What does the "100" in the motor designation H100-5 stand for?
    a. It is the peak thrust in pounds of the rocket motor.
    b. It is the rocket motor burn times in seconds.
    c. It is the average thrust in Newtons of the rocket motor.

5. What does the "5" stand for in the motor designation H100-5 stand for?
    a. It is the rocket motor burn time.
    b. It is the average thrust of the rocket motor.
    c. It is the ejection charge delay time.

6. What are the units of measurement for the "100" in the motor designation H100-5?
    a. Newtons per second.
    b. Newtons
    c. Newtons-seconds

7. What is the total impulse for a "J" rocket motor?
    a. 640.00 Newton-seconds
    b. 1280.00 Newton-seconds
    c. 2560.00 Newton-seconds

8. When clustering combinations of black powder and composite motors, which type of rocket motor should be ignited first?
    a. Composite rocket motors should be ignited first.
    b. Black powder should be ignited first.
    c. It does not matter which motors are ignited first.

9. Why should composite motors be ignited first in a mixed composite and black powder cluster?
    a. Composite motors are more difficult and take longer to ignite.
    b. Composite motors are more likely to cato than black powder motors.
    c. The exhaust products from black powder motors prevent composite motor ignition.

10. What is the advantage of using a “relay” type launch control?
    a. It is cheaper than a non relay launch control.
    b. The relay allows a better indication of igniter continuity.
    c. It can deliver more power to the rocket igniters.

11. Which of the following adhesives is the best choice for engine mount construction?
    a. Epoxy adhesives.
    b. Cyanoacrylate glues (super glue)
    c. “Hot melt” adhesives.

12. A small hole is typically recommended near the top, but below the nose cone or payload section shoulder, of a HPR booster section. Why?
    a. This hole allows excessive ejection charge pressures to vent to reduce shock cord stress.
    b. The hole is used to give air pressure readings for onboard altitude meters.
    c. The hole vents internal air pressure as the rocket gains altitude to prevent internal air pressure from prematurely separating the model.

13. Which of the following is the preferred method for attaching fins to a HPR.
    a. Tube surface mounting.
    b. Wedge mounting.
    c. Through the wall mounting.

14. Igniters for clustered rocket motors should be wired together in:
    a. Series.
    b. Parallel.
    c. Short circuit/open circuit.

15. When should igniters installed in rocket motors be checked for continuity?
    a. Any time
    b. Only in an enclosed shelter.
    c. Only on the launch pad ready for launch.

16. During boost a rocket powered by a solid rocket motor tends to become:
    a. Less stable in flight.
    b. More stable in flight.
    c. No change in stability.

17. An unstable rocket can usually be made more stable by:
    a. Using a shorter nose cone.
    b. Increasing the size of the aft fins.
    c. Using a larger, heavier rocket motor.

18. Rocket stability can be estimated by:
    a. Center of pressure.
    b. Stability cannot be estimated before a test flight.
    c. Determining the relative positions of the centre of pressure and centre of gravity.

19. Which of the following adhesives should not be used on rubber (or elastic) shock cord components?
    a. Epoxy adhesives.
    b. Cyanoacrylate glues (super glue)
    c. Aliphatic resin based glues.

20. The centering rings provided with your high power kit are a loose fit around the motor tube. Which of the following adhesives is the best choice for a strong joint?
    a. Aliphatic resin based glues.
    b. Epoxy adhesives.
    c. “Hot melt” adhesives.

End Part A

PART B (Safety Code)

1. When shall the motor igniter(s) be installed in a HPR motor?
    a. At the launcher or a designated area.
    b. When the motor is installed in the rocket.
    c. neither a or b.

2. When shall firing circuits be armed?
    a. When testing igniter continuity.
    b. When the rocket is in the launching position.
    c. Both a and b.

3. What is the maximum altitude allowed for flying HPR's if there is a cloud ceiling of 3000 feet.
    a. 3500 feet.
    b. To the limit of the CASA waiver.
    c. Neither a or b.

4. What is the minimum distance for smoking (or open flames) from HPR motors, motor reloading kits and pyrotechnic modules?
    a. 8 meters
    b. 25 meters
    c. There is no minimum distance.

5. When is it permissible to consume alcohol when prepping or launching HPR's?
    a. When the preparation is done the day before the launch.
    b. If the blood alcohol level is below .05
    c. It is never permitted.

6. How close can spectators be to a HPR launch?
    a. At the distance defined by, and behind, the Safety Area.
    b. At the spectators discretion.
    c. 8 meters

7. Which of the following is a requirement for HPR certification?
    a. The ability to understand written English instructions.
    b. A minimum of 18 years of age.
    c. An Australian citizen.

8. Which of the following statements are true concerning the definition of a HPR motor?
    a. Total impulse is more than a 160 Newton-seconds.
    b. The motor uses a "composite" propellant.
    c. Both a and b.

9. A launch site is defined as containing areas for which of the following activities?
    a. Launching.
    b. Recovery
    c. Parking
    d. All of the above.

10. What is the responsibility of the RSO (Range Safety Officer)?
    a. To ensure that the range is operated safely and legally.
    b. To ensure the launch pad runs quickly and smoothly.
    c. To ensure recovery of rockets.

11. What is the CASA maximum ceiling height allowed in controlled airspace?
    a. 122 meters.
    b. 250 meters.
    c. 400 meters.

12. When does CASA permit HPR launching?
    a. Anytime no waiver needed.
    b. Only at approved CASA areas.
    c. Within 5kms of an aerodome.

13. How many hours notice does CASA require before a HPR launch?
    a. 12 hours
    b. 24 hours.
    c. 7 days.

14. When does FESA have the authority to shut down a rocket launch?
    a. Never.
    b. 24 hour written notice.
    c. Anytime.

15. 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 person that is a member of a rocketry club and is certified to fly high power rocketry.

16. A high power rocket may be constructed of what materials?
    a. Paper, wood, fiberglass or plastic with a minimum amount of metallic parts.
    b. Paper wood, fiberglass, plastic and aluminum.
    c. There are no restrictions on construction materials.

17. When can a high power rocket be flown through cloud?
    a. When authorized to do so by the Range Safety Officer (RSO).
    b. When authorized to do so by the Range Safety Officer (RSO) and with written permission from CASA.
    c. Neither a or b.

18. A lockable box for storing black powder motors less than 25kg should not be made from:
    a. Wood
    b. Plastic
    c. Steel.

19. Which of the following can be used to launch a HPR:
    a. A suitable size rod.
    b. A launching rail system.
    c. Both a and b.

20. What is the maximum launch angle from vertical for a high power rocket?
    a. 30°
    b. 20°
    c. There is no maximum launch angle.

End Part B

LEVEL 1 EXAM QUESTION ANSWERS

Answers: Part A (Technical)

1. **a**. NH_4ClO_4 is the chemical formulation for Ammonium Perchlorate.
2. **c.** Newton's Third Law. Applying force in one direction always results in an equal force in the opposite direction.
3. **b.** In a rocket motor designation the alphabetical character indicates the total impulse(or total power) for the rocket motor.
4. **c.** In a rocket motor designation the number before the dash is the average thrust in Newtons of the rocket motor. Divide this number by 4.45 for the average thrust in pounds.
5. **c.** In the standard designation system for rocket motors the number after the dash indicates the delay in seconds between rocket motor burn out and ejection charge operation.
6. **b.** In a rocket motor designation the number before the dash is the average thrust in Newtons of the rocket motor.
7. **b.** In a rocket motor designation the alphabetical character indicates the total impulse or total power for the rocket motor.
8. **a.** Composite rocket motors are harder to ignite than black powder motors.
9. **a.** Composite rocket motors are harder to ignite than black powder motors.
10. **c.** A relay launch system uses a relay to switch the power needed for rocket motor ignition.
11. **a.** Epoxies can be used to easily form fillets at the bond joints which provides an increase in strength.
12. **c.** Air pressure external to the rocket decreases as the rocket ascends. Trapped pressure within the model can prematurely separate the model. The hole vents this internal air pressure to prevent separation.
13. **c.** Through the wall mounting is stronger because the model is supported and attached to the rocket at two locations.
14. **b.** If the igniters are wired in series the first igniter to burn out opens the circuit preventing any other igniters from receiving any electrical power. Parallel connections allow all of the igniters to independently receive electrical power.
15. **c.** Continuity is typically checked by the launch controller when the rocket is placed on the launch pad.
16. **b.** During powered flight a solid rocket motor consumes its fuel causing the aft end of the rocket to become lighter. This moves the cg forward and enhances stability.
17. **b.** To make the rocket stable the centre of pressure(Cp) must be moved aft of the centre of gravity(Cg). Adding larger fins on the aft portion of the model moves the center of pressure aft.
18. **c.** Determining the relative positions of the centre of pressure and centre of gravity.
19. **b.** Cyanoacrylate glues will chemically attack rubber or elastic shock cord components allowing them to break when stretched.
20. **b.** Epoxies can be used to easily form fillets at the bond joints which provides an increase in strength. Epoxies also bridge gaps in loose fitting parts to improved bond strength.

Answers : Part B (Safety Code)

1. a
2. b
3. c
4. a
5. c
6. a
7. b
8. a
9. d
10. a
11. a
12. b
13. b
14. c
15. c
16. a
17. c
18. c
19. c
20. a

LEVEL 2 CERTIFICATION QUESTIONS

PART A (Technical Questions)

1. 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.

2. What are the three forces acting upon a rocket during the course of its flight?
    a. Thrust, rocket diameter and finish.
    b. Nose cone shape, thrust and drag.
    c. Gravity, thrust and aerodynamic drag.

3. What are the 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, weight and aerodynamic drag.

4. For an inherently stable rocket, what is the relationship of center of gravity (CG) to the center of pressure (CP)?
    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 be in front of the fins of a rocket.

5. 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.

6. What is the "rule-of-thumb" for a stable rocket?
    a. That the center of gravity is one body diameter in front of the center of pressure.
    b. That the center of gravity is at the same point as the center of pressure.
    c. There is no rule-of-thumb because there are too many variables.

7. When determining the center of gravity (CG) of a rocket with a heavier motor at the launch site, one can:
    a. Install the motor, recovery system and payload and determine the balance point of the rocket as it is ready for flight.
    b. Balance the rocket with an empty motor 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 more powerful motor because it has more thrust.

8. What happens to the center of gravity (CG) of a rocket during a solid rocket motor's thrusting phase?
    a. The Center of gravity stays the same.
    b. The Center of gravity shifts forward.
    c. The center of gravity shifts aft.

9. 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.

10. 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.

11. 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 n use smaller fins, add weight to the nose.
    c. Make the rocket shorter n change the number of fins, use a longer launch rod,

12. What is the definition of coefficient of drag (Cd)?
    a. A dimensionless number that represents the effect of gravity and Mach number of the rocket.
    b. A dimensionless number representing the rocket configuration, Mach number and angle of attack.
    c. A dimensionless number that represents the friction of the launcher and launch velocity.

13. What happens to the coefficient of drag (Cd) as the rocket approaches the speed of sound?
    a. The Cd decreases.
    b. The Cd stays the same.
    c. The Cd increases.

14. For a subsonic rocket, what major factors affect the coefficient of drag (Cd)?
    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.

15. 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.

16. What is the function of a motor liner and the O-ring seals in a solid rocket motor?
    a. To hold all of 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.

17. What is the most common oxidizer in commercially available high power composite solid rocket motors?
    a. Ammonium Perchlorate.
    b. Ammonium Nitrate.
    c. Ammonium Chlorate.

18. A small hole is typically recommended near the top, but below the nosecone or payload section, of a high power rocket's booster section. Why?
    a. This hole allows excessive ejection charge pressures to vent to reduce shock cord stress.
    b. The hole is used to give air pressure readings for on-board altimeters.
    c. The hole vents internal air pressure as the rocket gains altitude to prevent premature separation.

19. A rocket with a motor cluster consisting of a central composite motor and four black powder motors using thermalite igniters or electric matches:
    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.

20. 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 unit weight of propellant.
    c. Dependent on the diameter and length of the propellant grain.

21. In general terms, the total impulse of a rocket motor can be described as:
    a. The product of the average motor thrust and its burn time.
    b. The product of the propellant weight and its burn time.
    c. The product of the propellant weight and the motor thrust.

22. 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

23. Which motor has a higher total impulse?
    a. J200
    b. J400
    c. K200

24. Which motor has a higher average thrust?
    a. J200
    b. J400
    c. K200

25. What is the difference between a J640 and a J320 high power rocket motor (assume full 1280 Newton-second J motors)?
    a. The J320 burns out twice as fast as the J640.
    b. There is no difference between the motors, the numbers are manufacturer reference only.
    c. The J640 burns out twice as fast as the J320.

26. Which of the following has a total impulse in the J motor range?
    a. It = 600 Newton-seconds
    b. It = 1000 Newton-seconds
    c. It = 1290 Newton-seconds

27. 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.

28. What does the motor designation I220-8 mean?
    a. The motor is in the I impulse range with an average thrust of 220 Newtons and an 8 second delay from motor ignition.
    b. The motor is in the I impulse range, having a total impulse of 620 Newton-seconds with an average thrust of 220 Newtons and an 8 second delay from motor burn-out.
    c. The motor is in the I impulse range with an average thrust of 220 Newtons and an 8 second ejection delay from motor burn-out.

29. 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.

30. What is the purpose of a launch lug?
    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.

31. A rocket with a motor cluster consisting of a central composite 54mm J415 motor and four 29mm G80 composite motors using thermalite igniters or electric matches:
    a. will result in all motors starting about the same time.
    b. will result in the J415 motor starting first followed by the G80's.
    c. will result in the G80's starting first followed by the J415.

32. What can happen if all the motors of a cluster do not ignite at launch?
    a. Nothing, the rocket is inherently stable.
    b. The rocket may not fly straight.
    c. The rocket will shred.

33. 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.

34. 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.

35. What is the primary requirement for a rocket motor igniter?
    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.

End Part A

PART B (Safety Code)

1. 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. Both a and b.

2. What are the rocket motor criteria (minimum) that defines 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.
    c. Both a and b.

3. What is the lower weight limit of a high power rocket?
    a. A rocket weighing more than 1500grams.
    b. A rocket weighing less than 20kg.
    c. Both a and b.

4. When is a 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. A recovery device is always necessary.

5. A high power rocket may be constructed of what materials?
    a. Paper, wood, fiberglass or plastic with a minimum amount of metallic parts.
    b. Paper wood, fiberglass, plastic and aluminum.
    c. There are no restrictions on construction materials.

6. What is a high power rocket motor?
    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.

7. What are the structural or load-bearing parts of a high power rocket?
    a. Nose cone, body tube and motor mount.
    b. Nose cone, body tube and fins.
    c. Nose cone, motor mount and fins.

8. 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 person that is a member of a rocketry club and is certified to fly high power rocketry.

9. 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.

10. When must the stability of a rocket be determined?
    a. If the safety monitor requests it.
    b. When designing a new rocket.
    c. Before its first flight, except when launching a rocket of already proven stability.

11. What is the maximum weight of a high power rocket?
    a. Less than maximum weight recommended by the motor manufacturer for a given motor.
    b. Less than 50kg.
    c. There is no maximum high power rocket weight.

12. When is it permissible to catch a high power rocket?
    a. If the rocket weights less than 2.2 pounds or 1 kg.
    b. It is never permissible to catch a high power rocket.
    c. Neither a or b.

13. What payloads are not permitted in a high power rocket?
    a. Payloads that are flammable or explosive or intended to cause harm.
    b. Vertebrate animals.
    c. Both a and b.

14. When must a high power rocket launching device incorporate a blast deflector?
    a. When necessary to prevent the rocket motor's exhaust from impinging on flammable materials.
    b. All launch systems must incorporate a blast deflector.
    c. When the design of the launch device requires it.

15. What is the maximum launch angle from vertical for a high power rocket?
    a. 30°
    b. 20°
    c. There is no maximum launch angle.

16. What are the elements of an ignition system?
    a. Remotely controlled, electrically operated, a launch switch that returns to OFF when released.
    b. Remotely controlled, electrically operated and a removable safety interlock in series with the launch- switch.
    c. Remotely controlled, electrically operated, a launch switch that returns to OFF when released and a removable safety interlock in series with the launch switch.

17. When can a high power rocket be flown through cloud?
    a. When authorized to do so by the Range Safety Officer (RSO).
    b. When authorized to do so by the Range Safety Officer (RSO) and with written permission from CASA.
    c. Neither a or b.

18. What is the limit of surface wind for launching a high power rocket?
    a. 42kph.
    b. 32kph.
    c. 22kph.

19. When/What is the minimum distance from an occupied building or public highway for a launch site?
    a. 260 meters.
    b. 460 meters.
    c. No Minimum distance.

20. When may a high power rocket be launched?
    a. After warning the spectators and giving a 5 second countdown.
    b. When all systems are ready and after a 5 second countdown.
    c. After informing & getting permission and attention from the RSO.

21. What permit must be obtained to purchase model rocket and “Easy Access” high power rocket re-load engines?
    a. Blasting Permit from authorized blasting operator.
    b. No Permit required.
    c. Pyrotechnics Operators Permit from Department of Consumer Employment and Protection.

22. What quantity of rocket motors, motor reloading kits and pyrotechnic modules may be stored in an indoor magazine?
    a. 20kg.
    b. 35kg.
    c. 50kg.

23. When may a solid propellant high power rocket motor be shipped and stored with the igniter installed?
    a. It is never permissible to ship or store a solid propellant high power rocket motor with the igniter in place.
    b. When the rocket will be launched within 48 hours of igniter installation.
    c. Neither a or b.

24. What is the age limit Perth Advanced Rocketry Club Inc. 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.

25. What Australian organizations may currently certify users of high power rocket motors?
    a. Perth Advanced Rocketry Club Inc.
    b. The Australian Rocketry Association.
    c. Both a and b.

End Part B

LEVEL 2 EXAM QUESTION ANSWERS

Answers: Part A (Technical)

1. **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.
2. **c.** Gravity, thrust and drag are the forces acting on a rocket.
3. **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.
4. **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)n 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.
5. **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.
6. **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.
7. **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.
8. **b.** As the propellant burns the motor gets lighter and thus moves the balance point or center of gravity (CG) forward, This is why a marginally stable rocket will "act squirrelly" at launch, then stabilize and fly straight.
9. **b.** Adding enough weight to the nose will shift the center of gravity (CG) forward of the center of pressure (CP).
10. **b.** Moving the CG forward requires judicious design changes. The following are given as "rules-of-thumb," n Adding weight to the nose moves the CG forward by counterbalancing the rocket. Think of the rocket as a lever' making the rocket longer shifts the CG forward by
making the lever longer. Using a smaller (or lighter) motor reduces the weight aft thus shifting the CG forward.
11. **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. This alone is generally not preferred because the CG is also shifted aft and CP/CG stability relationship may be compromised.
12. **b.** The coefficient of drag (Cd) is a number that is used in equations for calculating the aerodynamic performance of a rocket. Values that make up the Cd are the rocket configuration (nose cone shape, airframe diameter(s), transition sections, fin size and sharpen etc.), the rocket velocity as Mach number and the angle of attack.
13. **c.** The coefficient of drag (Cd) increases and can be greater than 1 as the rocket exceeds Mach 1.
14. **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 effects the airflow over the front of the nose cone. The fin shape and fin area factor into the total surface area.

15. **c.** The three phases of flight of a high power rocket: (1) Powered flight - the period of time when the rocket motor is producing thrust against gravity and drag. (2) Un-powered ascent - the period after powered flight where the rockets momentum allows the rocket to coast to peak altitude and is effected by gravity and drag, (3) Descent - the return of the rocket to earth effected by gravity and drag.
16. **c.** The liner serves to keep the burning propellant (typically >5000°F) from touching the motor case (aluminum melts at 1075-F) while the Orings seal the ends to keep the hot gasses where they belong, that is going out of the nozzle.
17. **a.** Ammonium Perchlorate is NH_4ClO_4 and is used in practically all modern solid rocket motors.
18. **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 holes. Use caution in locating the hole so the nose cone or payload coupler does not block the hole. Be sure to position the hole such that ejection charge pressure is not vented before recovery system deployment.
19. **c.** black powder motors do not have a significant start up time and will ignite as soon as a 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.
20. **b.** specific impulse is a term used to define the efficiency of a rocket propellant and is the total impulse derived from a given mass of propellant.
21. **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.
22. **b.** Multiply the average thrust (100 Newtons) by the burn time (4 seconds) to get the total impulse of 400 newton-seconds.
23. **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.
24. **b.** Even though the total impulse of the K motor is greater than the J motor, the J motor's average thrust is 400 Newton's versus the K motor's 200 Newtons.
25. **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 divided by 640 Newtons = 2 seconds, and for the J320 is: 1280 Newton-seconds divided by 320 Newtons = 4seconds.
26. **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.
27. **c.** The Newton is an international (metric) unit of force and is the force required to accelerate one kg (2.2 lbs) one meter (39 inches) per second per second.
28. **c.** This is an I motor with a total impulse range of 320.01 to 640 Newton-seconds, an average thrust of 220 Newton's and an ejection delay of 8 seconds from burn-out.
29. **c.** The purpose of the launch rod, rail or tower is to guide the rocket at the beginning of its flight to allow it to gain sufficient velocity for a stable flight. This 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,
30. **b.** The launch lug attaches the rocket to the launch rod or rail allowing the rocket to be guided by the rod or rail at launch.
31. **c.** Composite (Ammonium Perchlorate) motors require heat and pressure to ignite. The motor core diameter is smaller in the 29mm G80 motors and heat and pressure is more concentrated resulting in faster ignition of the motors.

32. **b.** Not having ignition of all clustered motors results in the thrust being unsymmetrical. This unbalanced thrust may force the rocket to fly in an unanticipated arc that will not achieve a vertical flight.
33. **a.** A shred happens when the rocket is improperly built or has a rocket motor too powerful for that particular rocket. The typical shred sequence is that the velocity of the rocket has increased to a point where airframe, fins or other structural parts cannot take the loads. When that part fails, it typically causes the rocket to become unstable resulting in the rapid destruction of the rocket.
34. **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.
35. **a.** A motor igniter must deliver sufficient heat to the propellant to get it ignited. This may be in the form of hot gas, hot burning particles, a hot wire or a combination of all three.

Answers : Part B (Safety Code)

1. c.
2. c.
3. a.
4. c.
5. a.
6. b.
7. b.
8. c.
9. a.
10. c.
11. a.
12. b.
13. c.
14. b.
15. b.
16. c.
17. c.
18. b.
19. b.
20. c.
21. c.
22. c.
23. a.
24. b.
25. a.