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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **1a** | From tables or calculator:  P(*X* 9) = 0.0681; P(*X* 10) = 0.0318 | **M1** | 1.1b | 4th  Carry out one-tailed tests for the mean of a Poisson distribution |
| Hence critical region is *X* 10 | **A1** | 2.2b |
|  | **(2)** |  |  |
| **1bi** | A Type I error is when you incorrectly reject the null hypothesis. | **B1** | 1.2 | 4th  State a definition of a Type I error |
|  | **(1)** |  |  |
| **1bii** | 0.0318 | **B1** | 1.2 | 5th  Explain a Type I error in context |
|  | **(1)** |  |  |
| (4 marks) | | | | |
| Notes  **1a:** **M1** for either 0.0681 or 0.0318  **A1** for *X* 10 (allow any letter but do not allow probability statements)  **1bi:** **B1** for a correct statement (allow equivalent statements)  **1bii:** **B1** for 0.0318 or ft *their* part **a** | | | | |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **2a** | Attempts to find critical region at either end – seen or implied. | **M1** | 1.1a | 5th  Explain a Type I error in context |
| P(*Y* = 0) = 0.0135 | **A1** | 1.1b |
| P(*Y* 8) = 0.0048 | **A1** | 1.1b |
| P(Type I error) = 0.0135 + 0.0048 = 0.0183 | **A1** | 2.2b |
|  | **(4)** |  |  |
| **2bi** | A Type II error is when you accept H0 but H0 is in fact false. | **B1** | 1.2 | 4th  State a definition of a Type II error |
|  | **(1)** |  |  |
| **2bii** | P(1 *Y* 7|*p* = 0.4) | **M1** | 1.1a | 6th  Calculate the value of a Type II error using conditional probability |
| = P(*Y* 7|*p* = 0.4) – P(*Y* = 0|*p* = 0.4) | **M1** | 1.1b |
| = 0.9877 − 0.0060 | **A1** | 1.1b |
| P(Type II error) = 0.9817 | **A1** | 2.2b |
|  | **(4)** |  |  |
| (9 marks) | | | | |
| Notes  **2a:** **M1** for clear attempt to find critical region at either end  **A1** for 0.0135  **A1** for 0.0048  **A1** for adding ft *their* 0.0135 and 0.0048 as long as both < 0.025  **2bi:** **B1** for correct statement (accept equivalent statements)  **2bii:** **M1** for correct conditional probability statement (s.o.i.)  **M1** (dep)for correct method to calculate required probability  1st **A1** for either probability correct  **A1** for correct final answer | | | | |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **3a** | Assume H0 (*μ* = 550) is true and use model. | **B1** | 3.3 | 6th  Recognise when the central limit theorem is required |
| *z* = –1.6449 | **B1** | 2.2b |
|  | **M1** | 1.1b |
| *c* = 548.72… = 548.7 so critical region is | **A1** | 1.1b |
|  | **(4)** |  |  |
| **3b** | P(Type II error) = | **M1** | 1.1a | 6th  Calculate the value of a Type II error using conditional probability |
| = 0.6507 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **3c** | Significance level should be **increased** since this will decrease the probability of a Type II error. | **B1** | 2.4 | 5th  Explain a Type II error in context |
|  | **(1)** |  |  |
| (7 marks) | | | | |
| Notes  **3a:** **B1** for use of CLT to define distribution of  **B1** for –1.6449  **M1** for standardising and equal to –1.6449  **A1** for awrt 548.7, must be a critical region  **3b:** **M1** for a correct probability statement, ft *their* part **a**  **A1** for awrt 0.651 if 1 d.p. rounded value in **a** used in **b**. Allow unrounded values from **a** if prob correct in **b,** e.g. 548.725 gives prob of 0.6387  **3c:** **B1** for **increase**, with reason, e.g. the probability of a Type II error will decrease (accept equivalent statements) | | | | |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **4a** | The size of a test is the probability of rejecting the null hypothesis when it is true [P(Type I error)]. | **B1** | 1.2 | 5th  Know the definition of the size of a test |
|  | **(1)** |  |  |
| **4b** | The power of a test is the probability of rejecting the null hypothesis when it is not true [1 – P(Type II error)]. | **B1** | 1.2 | 5th  Know the definition of the power of a test |
|  | **(1)** |  |  |
| **4ci** | P(*X* 4) = 0.1730  P(*X* 3) = 0.0818 | **M1** | 1.1b | 4th  Carry out one-tailed tests for the mean of a Poisson distribution |
| Hence critical region is *X* 3 | **A1** | 2.2b |
| Size = 0.0818 | **A1** | 1.2 |
|  | **(3)** |  |  |
| **4cii** | Power = P(H0 rejected|*λ* = 7.5) = P(*X* 3|*λ* = 7.5) | **M1** | 1.1a | 7th  Use standard probability distributions to find the power of a test |
| = 0.0591 | **A1** | 1.1b |
|  | **(2)** |  |  |
| (7 marks) | | | | |

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| Notes  **4a:** **B1** for correct explanation. P(Type I error) is *not* sufficient on its own  **4b:** **B1** for correct explanation. 1 – P(Type II error) is *not* sufficient on its own  **4ci:** **M1** for clear attempt to find critical region  **A1** for *X* 3  **A1ft** *their* critical region  **4cii:** **M1** for correct conditional probability statement  **A1** for awrt 0.0591 |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **5a** | *Y* ~ B(15, *p*)  Power function = P(*Y* 2|*Y* ~ B(15, *p*)) | **M1** | 3.3 | 7th  Be able to find and/or use the power function  of a test |
|  | **M1** | 1.1b |
|  | **M1** | 1.1a |
|  | **A1** | 2.1 |
|  | **(4)** |  |  |
| **5b** |  | **M1** | 1.1b | 7th  Be able to find and/or use the power function  of a test |
| = 0.1268 | **A1** | 1.1b |
|  | **(2)** |  |  |
| (6 marks) | | | | |
| Notes  **5a:** 1st **M1** for set up of problem  2nd **M1** for attempt at binomial terms, at least two coefficients and pairs of powers correct  3rd **M1** for attempt to simplify *their* binomial expression, at least one line of working correct  **A1** for complete correct generation of given power function, must be convincing  **5b:** **M1** for substituting into *given* power function  **A1** for awrt 0.127 | | | | |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **6a** | *X* ~ Geo(0.15) | **B1** | 3.3 | 8th  Carry out hypothesis tests for the parameter *p* of the geometric distribution |
| P(*X* *c*) < 0.05 | **M1** | 2.4 |
| P(*X* *c*) = 0.85*c* – 1 | **M1** | 3.4 |
|  | **M1** | 1.1b |
| hence critical region is *C* 20 | **A1** | 2.2b |
|  | **(5)** |  |  |
| **6b** | Size = [0.8519 = 0.045599…] = 0.0456 | **B1** | 1.1b | 5th  Know the definition of the size of a test |
|  | **(1)** |  |  |
| **6c** | (1 – *p*)19 | **B1** | 1.1b | 7th  Be able the find and/or use the power function of a test |
|  | **(1)** |  |  |
| **6d** | *Y* ~ B(31, 0.15) and seek *d* such that P(*Y* *d*) < 0.05 | **M1** | 3.3 | 5th  Know the definition of the size of a test |
| P(*Y* 1) < 0.05 therefore critical region *Y* 1 | **M1** | 1.1b |
| P(*Y* 1) = 0.0420 | **A1** | 1.1b |
|  | **(3)** |  |  |

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| **6e** | Power = P(reject H0 when it is false|*Y* ~ B(31, *p*)) | **M1** | 2.1 | 7th  Be able the find and/or use the power function of a test |
|  | **M1** | 1.1b |
| \* | **A1** | 1.1b |
|  | **(3)** |  |  |
| **6f** | George’s test has a smaller size so is better | **B1** | 2.2a | 8th  Be able to comment on the test using power functions and different values for the parameter |
| Power of George’s test: 0.8830(1 + 30 × 0.12) = 0.0994 | **B1** | 1.1b |
| Power of Jack’s test: 0.8819 = 0.0881 | **B1** | 1.1b |
| So for *p* = 0.12, George’s test is recommmended | **B1** | 2.2b |
|  | **(4)** |  |  |
| (17 marks) | | | | |
| Notes  **6a:** **B1** for *X* ~ Geo(0.15)  **M1** for correct probability statement  **M1** for correct calculation  **M1** for attempt to solve *their* 0.85*c* – 1 < 0.05  **A1** for critical region, answer must be an integer  **6b:** **B1ft** *their* part **a** if < 0.05  **6c:** **B1ft** *their* part **a**  **6d:** **M1** for setting up the problem  **M1** for attempt to find critical region, consistent with *their* set up  **A1** for 0.0420  **6e:** **M1** for correct conditional probability statement  **M1** for attempt to use binomial expansion with *their* critical region from part **d**  **A1** for complete correct generation of given power function, must be convincing  **6f:** **B1ft** *their* part **b** and part **d**  **B1** no ft from incorrect part **e**, must use given power function  **B1ft** *their* part **c**  **B1** for correct conclusion (George’s test), ft only if conclusion consistent | | | | |