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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **1a** | The sample mean… | **B1** | 1.2 | 4thBe able to quote the central limit theorem |
| …is (approximately) normally distributed with mean *μ* and variance   | **B1** | 1.2 |
|  | **(2)** |  |  |
| **1b** | The sample must be random | **B1** | 1.2 | 5thKnow the conditions for the use of the central limit theorem |
|  | **(1)** |  |  |
| (3 marks) |
| Notes**1a** **B1** must state *sample* mean (accept )**B1** parameters must be given. Accept standard deviation rather than variance**1b** **B1** for sample is random |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **2a** |   | **M1** | 3.1a | 7thApply the central limit theorem to a range of probability distributions |
|  | **M1** | 1.1b |
| = 0.1469 | **A1** | 1.1b |
|  | **(3)** |  |  |
| **2b** | No: The population is normally distributed so the sample mean is also normally distributed. | **B1** | 2.4 | 5thKnow the conditions for the use of the central limit theorem |
|  | **(1)** |  |  |
| (4 marks) |
| Notes**2a** **M1** for attempt to find distribution of  using given parameters, must divide by 10**M1** for attempt to find **A1** awrt 0.147**2b** **B1** for ‘No’ with correct reason |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **3a** |  | **M1** | 3.1a | 7thApply the central limit theorem to a range of probability distributions |
|  | **M1** | 1.1b |
| = 0.0268 | **A1** | 1.1b |
|  | **(3)** |  |  |
| **3b** | Require  | **M1** | 3.1a | 8thRecognise and apply the central limit theorem in contextualised situations |
| *Z* = (–)2.3263 | **B1** | 1.1a |
|   | **M1** | 1.1b |
|   | **M1** | 1.1b |
| *n* = 73 | **A1** | 3.2a |
|  | **(5)** |  |  |
| (8 marks) |
| Notes**3a** **M1** for attempt to find distribution of  using given parameters, must divide by 50**M1** for attempt to find **A1** awrt 0.027**3b** **M1** for probability statement in terms of *Z* and using **B1** for correct *Z* value (from tables); accept + or – here**M1** for attempt to solve resulting equation using *their* *Z* ( must now be –)**M1** for value for  leading to value for *n***A1ft** *their Z*  value if all M marks awarded (answer must be an integer) |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **4a** | 0.1 + *k* + 2*k* + 0.3 + 0.24 = 1 | **M1** | 1.1b | 1stUnderstand how to find unknowns from a probability mass function |
| Hence *k* = 0.12 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **4bi** | E(*X*) = 1 × 0.1 + 2 × 0.12 + 4 × 0.24 + 5 × 0.3 + 6 × 0.24 | **M1** | 1.1b | 2ndCalculate the mean of a discrete random variable |
| = 4.24 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **4bii** | Var(*X*) = 12 × 0.1 + … + 62 × 0.24 – 4.242 | **M1** | 1.1b | 3rdCalculate the variance of a discrete random variable |
| = 2.5824 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **4c** | CLT states that the sample mean is approximately normally distributed. | **B1** | 1.2 | 6thRecognise when the central limit theorem is required |
|  | **(1)** |  |  |
| **4d** |   | **M1** | 3.1a | 7thApply the central limit theorem to a range of probability distributions |
|  | **M1** | 1.1b |
| = 0.9265 | **A1** | 1.1b |
|  | **(3)** |  |  |

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| **4e** | Estimate is fairly accurate since *n* is large. | **B1** | 2.4 | 5thKnow the conditions for the use of the central limit theorem |
|  | **(1)** |  |  |
| (11 marks) |
| Notes**4a** **M1** for attempt to add probabilities and equate to 1**A1** cao**4bi** **M1A1ft** from *their* *k***4bii** **M1A1ft** from *their k***4c** **B1** for completely correct reason**4d** **M1** for attempt to find distribution of  using calculated parameters, must divide by 80**M1** for attempt to find **A1ft** awrt 0.927 (ft *their* **4bi** and **4bii**)**4e** **B1** for correct statement including *n* is large |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **5** |   | **M1****A1** | 3.1a1.1b | 7thApply the central limit theorem to a range of probability distributions |
|  | **M1** | 1.1b |
| = 0.3300 | **A1** | 1.1b |
| (4 marks) |
| Notes1st **M1** for use of CLT with given Poisson parameters1st **A1** for completely correct normal distribution2nd **M1** for attempt to find  using *their* normal distribution2nd **A1** awrt 0.33 |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **6a** | Mean:   | **B1** | 1.1b | 6thCalculate the mean/variance of a geometric distribution |
| Variance:   | **B1** | 1.1b |
|  | **(2)** |  |  |
| **6b** |   | **M1****A1** | 3.1a1.1b | 7thApply the central limit theorem to a range of probability distributions |
|  | **M1** | 1.1b |
| = 0.1587 | **A1** | 1.1b |
|  | **(4)** |  |  |
| (6 marks) |
| Notes**6a** **B1** for correct mean**B1** for correct variance**6b** 1st **M1** for use of CLT with *their* Geo parameters1st **A1** for completely correct normal distribution2nd **M1** for attempt to find  using *their* normal distribution2nd **A1** awrt 0.159 |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **7** | Model is Negative B(8, 0.3) | **B1** | 3.3 | 8thRecognise and apply the central llimit theorem in contextualised situations |
|  | **B1** | 1.1b |
|  | **B1** | 1.1b |
|  | **M1****A1** | 3.1a1.1b |
|  | **M1** | 1.1b |
| = 0.145 | **A1** | 2.1 |
| (7 marks) |
| Notes**B1** for correct model**B1** for correct expectation**B1** for correct variance1st **M1** for use of CLT with *their* Negative B parameters1st **A1** for completely correct normal distribution2nd **M1** for attempt to find  using *their* normal distribution2nd **A1** cao |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **8a** |  | **M1** | 3.1b | 7thApply the central limit theorem to a range of probability distributions |
| = 0.007 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **8b** | The population is normally distributed. | **B1** | 2.4 | 5thKnow the conditions for the use of the central limit theorem |
|  | **(1)** |  |  |
| **8c** | Model is B(24, 0.2) | **B1** | 3.1b | 8thRecognise and apply the central llimit theorem in contextualised situations |
| Mean: 24 × 0.2 = 4.8Variance: 4.8 × 0.8 = 3.84 | **B1** | 1.1b |
|  | **M1** | 1.1b |
| = 0.057 | **A1** | 2.1 |
|  | **(4)** |  |  |
| (7 marks) |
| Notes**8a** **M1** for attempt to find **A1** awrt 0.007**8b** **B1** must state normally distributed**8c** **B1** correct model**B1** mean and variance both correct**M1** for attempt to find  using *their* model and mean/variance**A1** cao |