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### 1

<table>
<thead>
<tr>
<th>1</th>
<th>(i)(a) (1 - P(\leq 6) = 1 - 0.8675)</th>
<th>M1</th>
<th>1 – 0.9361 or 1 – 0.8786 or 1 – 0.8558: M1. .9721: M0</th>
<th>A1</th>
<th>Or 0.132 or 0.133</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b) (e^{-0.4} \frac{0.42^2}{2!} = 0.05795)</td>
<td>M1</td>
<td>Po(0.42) stated or implied</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ii)</td>
<td>E.g. “Contagious so incidences do not occur independently”, or “more cases in winter so not at constant average rate”</td>
<td>B2</td>
<td>Contextualised reason, referred to conditions: B2. No marks for mere learnt phrases or spurious reasons, e.g. not just “independently, singly and constant average rate”. See notes.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2

<table>
<thead>
<tr>
<th>2</th>
<th>(i) (B(10, 0.35)) (P(&lt; 3) = 0.2616)</th>
<th>M1</th>
<th>B(10, 0.35) stated or implied</th>
</tr>
</thead>
<tbody>
<tr>
<td>(ii) (\text{Binomial requires being chosen independently, which this is not, but unimportant as population is large})</td>
<td>B2</td>
<td>Focus on “Without replacement” negating independence condition. It doesn’t negate “constant probability” condition but can allow B1 if “selected”. See notes</td>
<td></td>
</tr>
</tbody>
</table>

### 3

<table>
<thead>
<tr>
<th>3</th>
<th>(i) (\frac{32 - 40}{9.5[06]} = \Phi^{-1}(0.2) = -0.842)</th>
<th>M1</th>
<th>Standardise and equate to (\Phi^{-1}), allow “1 –” errors, (\sigma^2), cc 0.842 seen</th>
</tr>
</thead>
<tbody>
<tr>
<td>(ii) (B(90, 0.2)) (\approx N(18, 14.4)) (1 - \Phi\left(\frac{19.5 - 18}{\sqrt{14.4}}\right) = 1 - \Phi(0.3953)) (= 1 - 0.6537 = 0.3463)</td>
<td>B1</td>
<td>Answer, 9.5 or in range [9.50, 9.51], c.w.o.</td>
<td></td>
</tr>
<tr>
<td>(\text{Binomial requires being chosen independently, which this is not, but unimportant as population is large})</td>
<td>B2</td>
<td>Contextualised reason, referred to conditions: B2. No marks for mere learnt phrases or spurious reasons, e.g. not just “independently, singly and constant average rate”. See notes</td>
<td></td>
</tr>
</tbody>
</table>

### 4

<table>
<thead>
<tr>
<th>4</th>
<th>(a) (\text{H}_0 : p = 0.4,) (\text{H}_1 : p &gt; 0.4)</th>
<th>B1</th>
<th>Fully correct, B2. Allow (\pi, p) omitted or (\mu) used in both, or &gt; wrong: B1 only. (x) or (\bar{x}) or 6.4 etc: B0</th>
</tr>
</thead>
<tbody>
<tr>
<td>(P(R \geq 11) = 0.0191) (&gt; 0.01)</td>
<td>B1</td>
<td>(P(\leq 10) = 0.9808, \text{and} &lt; 0.99, \text{or} z = 2.092) or (p = 0.018, \text{but not} P(\leq 11) = 0.9951 \text{or} P(= 11) = 0.0143)</td>
<td></td>
</tr>
<tr>
<td>(b) (\text{CR} R \geq 12 \text{and} 11 &lt; 12) (\text{Probability} 0.0049)</td>
<td>A1</td>
<td>Needs like-with-like, (P(R \geq 11)) or (\text{CR} R \geq 12)</td>
<td></td>
</tr>
</tbody>
</table>

### 5

<table>
<thead>
<tr>
<th>5</th>
<th>(i) (30 + 1.645 \times \frac{5}{\sqrt{10}} = 32.6) (\text{Therefore critical region is} 7 &gt; 32.6)</th>
<th>M1</th>
<th>30 + 5z/(\sqrt{10}), allow (\pm) but not just (\pm), allow (\sqrt{\text{errors}}) (x = 1.645) seen, allow –</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b) (P(I &lt; 32.6</td>
<td>\mu = 35) = 0.0645)</td>
<td>M1*</td>
<td>Critical value, art 32.6</td>
</tr>
</tbody>
</table>

### Notes
- Correct formula, any numerical condition but can allow B1 if “selected”. See notes.
- MR: 0.05: M1 A0 M1, 16.7 A1 FT
- Equate and solve for \(\mu\), from 30 or 35
- Answer, a.r.t. 21, c.a.o.
### 6 (a) Normal, mean 24 stated or implied

\[ N(24, 24) \]

\[ 1 - \Phi \left( \frac{30.5 - 24}{\sqrt{24}} \right) = 1 - \Phi(1.327) \]

\[ \approx 0.0923 \]

- **Mark Scheme:**
  - B1 Normal, mean 24 stated or implied
  - B1 Variance or SD equal to mean
  - M1 Standardise 30 with \( \lambda \) and \( \sqrt{\lambda} \), allow cc or \( \sqrt{\lambda} \) correct
  - A1 \( .130 \) or \( .1103 \); 30.5 and \( \sqrt{\lambda} \) correct
  - A1 Answer in range \([0.092, 0.0925]\)

### 6 (b)(i) \( p \text{ or } np \) \([= 196]\) is too large

- **Mark Scheme:**
  - B1 Correct reason, no wrong reason, don’t worry about 5 or 15

### 6 (b)(ii) Consider \((200 - E)\)

\[ P(\geq 6) \approx 1 - 0.7851 \]

\[ = 0.2149 \]

- **Mark Scheme:**
  - M1 Consider complement
  - M1 Poisson tables used, correct tail, e.g. 0.3712 or 0.1107
  - A1 Answer a.r.t. 0.215 only

### 7 (a)

\[ H_0 : \mu = 56.8 \]

\[ H_1 : \mu \neq 56.8 \]

\[ \bar{X} = 17085/300 = 56.95 \]

\[ 300 \left( \frac{973847}{299} \right) - 56.95^2 \]

\[ = 295.563 \]

\[ 299 / 8637.2 \approx 0.003 \]

\[ z = 1.535 \]

\[ 1.535 < 1.645 \text{ or } 0.0624 > 0.05 \]

- **Mark Scheme:**
  - B2 Both correct
  - B1 One error: B1, but not \( x \), etc
  - M1 56.95 or 57.0 seen or implied
  - A1 Biased \[ [2.8541] \]: M1M0A0
  - A1 Unbiased estimate method, allow if \( \frac{x}{299} \) seen anywhere
  - A1 Estimate, a.r.t. 2.86 [not 2.85]
  - A1 Standardise with \( \sqrt{300} \), allow \( \sqrt{n} \) errors, cc
  - A1 Compare explicitly \( z \) with 1.645 or \( p \) with 0.05, or \( 2p > 0.1 \), not from \( \mu = 56.95 \)

### 7 (b)

\[ CV = 56.8 \pm 1.645 \times \sqrt{\frac{2.8637}{300}} \]

\[ 56.96 > 56.95 \]

- **Mark Scheme:**
  - M1 Consistent first conclusion, needs 300, correct method and comparison
  - A1 FT Conclusion stated in context, not too assertive, e.g. “evidence that” needed

### 8 (i)

\[ \int_{-\infty}^{\infty} kx^{-a} \, dx = \left[ \frac{k}{-a + 1} \right]^{\infty}_{1} \]

- **Mark Scheme:**
  - M1 Correctly obtain \( k = a - 1 \)
  - B1 Integrate \( f(x) \), limits 1 and \( \infty \) (at some stage)
  - A1 Correctly obtain given answer, don’t need to see treatment of \( \infty \) but mustn’t be wrong. Not \( k = a - 1 \)

### 8 (ii)

\[ \int_{-\infty}^{\infty} x^{-\frac{3}{2}} \, dx = \frac{3}{-\frac{3}{2} + 1} = 1.5 \]

\[ \int_{-\infty}^{\infty} x^{-\frac{3}{1}} \, dx = \frac{3}{-\frac{3}{1} + 1} = 1.5 \]

- **Mark Scheme:**
  - M1 Integrate \( f(x) \), limits 1 and \( \infty \) (at some stage)
  - M1 \( x^3 \) is not MR
  - A1 Integrate \( x^2 f(x) \), correct limits
  - A1 Either \( \mu = 1.5 \) or \( E(X^2) = 3 \) stated or implied, allow \( k, k/2 \)
  - A1 Subtract their numerical \( \mu^2 \), allow letter if subs later
  - A1 Final answer \( 1/4 \) or 0.25 only, cwo, e.g. not from \( \mu = -1.5 \)

### 8 (iii)

\[ \int_{-\infty}^{\infty} (a - 1)x^{-a} \, dx = \left[ -x^{-a+1} \right]_{1}^{\infty} = 0.9 \]

\[ 1 - \frac{1}{2} = 0.5, 2^{-1} = 10 \]

\[ a = 4.322 \]

- **Mark Scheme:**
  - M1* Equate \( f(x) \), one limit 2, to 0.9 or 0.1.
  - dep*M1 Solve equation of this form to get \( 2^{a-1} = \text{number} \)
  - A1 indept Use logs or equivalent to solve \( 2^{a-1} = \text{number} \)
  - M1 Answer, a.r.t. 4.32. T&I: (M1M1) B2 or B0
Specimen Verbal Answers

1  α  “Cases of infection must occur randomly, independently, singly and at constant average rate”   B0
β  Above + “but it is contagious”  B1
γ  Above + “but not independent as it is contagious” B2
δ  “Not independent as it is contagious”  B2
ε  “Not constant average rate”, or “not independent” B0
λ  “Not constant average rate because contagious”  [needs more] B1
ζ  “Not constant average rate because more likely at certain times of year”  B2
μ  Probabilities changes because of different susceptibilities  B0
ν  Not constant average rate because of different susceptibilities B2
η  Correct but with unjustified or wrong extra assertion [scattergun] B1
θ  More than one correct assertion, all justified B2
π  Valid reason (e.g. “contagious”) but not referred to conditions B1

[Focus is on explaining why the required assumptions might not apply. No credit for regurgitating learnt phrases, such as “events must occur randomly, independently, singly and at constant average rate, even if contextualised.]

2  Don’t need either “yes” or “no”.
α  “No it doesn’t invalidate the calculation”  [no reason] B0
β  “Binomial requires not chosen twice” [false] B0
γ  “Probability has to be constant but here the probabilities change” B0
δ  Same but “probability of being chosen” [false, but allow B1] B1
ε  “Needs to be independently chosen but probabilities change” [confusion] B0
ζ  “Needs to be independent but one choice affects another” [correct] B2
η  “The sample is large so it makes little difference” [false] B0
θ  “The population is large so it makes little difference” [true] B2
λ  Both correct and wrong reasons (scattergun approach) B1

[Focus is on modelling conditions for binomial: On every choice of a member of the sample, each member of the population is equally likely to be chosen; and each choice is independent of all other choices.
Recall that in fact even without replacement the probability that any one person is chosen is the same for each choice. Also, the binomial “independence” condition does require the possibility of the same person being chosen twice.]
