

**A level Mathematics Practice Paper – Hypothesis testing – Mark scheme**

| Question    | Scheme                                                                                                                                 | Marks             |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| <b>1(a)</b> | $H_0 : p = 0.15 \quad H_1 : p \neq 0.15$                                                                                               | B1 B1             |
|             | $X \sim B(30, 0.15)$                                                                                                                   | M1                |
|             | $P(X \leq 1) = 0.0480$ or CR: $X = 0$                                                                                                  | A1                |
|             | $(0.0480 > 0.025)$                                                                                                                     |                   |
|             | not a significant result or do not reject $H_0$ or not in CR                                                                           | M1                |
|             | there is no evidence of a <u>change</u> in the <u>proportion of customers</u> <u>buying</u> an item <u>from the display</u> .          | A1ft              |
|             |                                                                                                                                        | <b>(6)</b>        |
| <b>1(b)</b> | $H_0 : p = 0.2 \quad H_1 : p > 0.2$                                                                                                    | B1                |
|             | Let $S$ = the number who buy sandwiches, $S \sim B(120, 0.2)$ ,                                                                        |                   |
|             | $S \approx W \sim N\left(24, \sqrt{19.2}^2\right)$                                                                                     | M1 A1             |
|             | $P(S \geq 31) = P(W \geq 30.5)$                                                                                                        | M1                |
|             | $= P\left(Z > \frac{30.5 - 24}{\sqrt{19.2}}\right)$ or $\frac{x - 0.5 - 24}{\sqrt{19.2}} = 1.2816$                                     | M1                |
|             | $[= P(Z > 1.48..)]$                                                                                                                    |                   |
|             | $= 1 - 0.9306$                                                                                                                         | M1                |
|             | $= 0.0694$ <span style="float: right;"><math>x = 30.1</math></span>                                                                    | A1                |
|             | $< 0.10$ so a significant result, there is evidence that more customers are purchasing sandwiches or the shopkeepers claim is correct. | B1ft              |
|             |                                                                                                                                        | <b>(8)</b>        |
|             |                                                                                                                                        | <b>(14 marks)</b> |

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| Question    | Scheme                                                                                                                                                                                                                                                                                                | Marks             |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| <b>2(a)</b> | A statement concerning a <b><u>population parameter</u></b>                                                                                                                                                                                                                                           | B1                |
|             | A critical region is the <u>range</u> / <u>set of values</u> / <u>answers</u> <b>or</b> a <u>test statistic</u> <b>or</b> <u>region/area</u> <b>or</b> <u>values</u> (where the test is significant)<br>that would lead to <u>the rejection of H<sub>0</sub></u> / <u>acceptance of H<sub>1</sub></u> | B1<br>B1          |
|             |                                                                                                                                                                                                                                                                                                       | <b>(3)</b>        |
| <b>2(b)</b> | $H_0 : p = 0.45 \quad H_1 : p < 0.45$ (or $p \neq 0.45$ )                                                                                                                                                                                                                                             |                   |
|             | $X \sim B(20, 0.45)$                                                                                                                                                                                                                                                                                  | M1                |
|             | $P(X \leq 5) = 0.0553$ <span style="float:right">CR <math>X \leq 4</math></span>                                                                                                                                                                                                                      | A1                |
|             | Accept $H_0$ . Not significant. 5 does not lie in the Critical region.                                                                                                                                                                                                                                | M1d               |
|             | There is no evidence that the proportion who voted for <u>Mrs George</u> is not 45% or there is evidence to support <u>Mrs George's</u> claim                                                                                                                                                         | A1cso             |
|             |                                                                                                                                                                                                                                                                                                       | <b>(4)</b>        |
| <b>2(c)</b> | $B(8, 0.45): P(0) = 0.0084$                                                                                                                                                                                                                                                                           | M1                |
|             | $B(7, 0.45): P(0) = 0.0152$                                                                                                                                                                                                                                                                           | A1                |
|             | Hence smallest value of $n$ is <b>8</b>                                                                                                                                                                                                                                                               | B1                |
|             |                                                                                                                                                                                                                                                                                                       | <b>(3)</b>        |
|             | Alternative                                                                                                                                                                                                                                                                                           |                   |
|             | $(0.55)^n < 0.01$                                                                                                                                                                                                                                                                                     | M1                |
|             | $n \log 0.55 < \log 0.01$                                                                                                                                                                                                                                                                             |                   |
|             | $n > 7.7\dots$                                                                                                                                                                                                                                                                                        | A1                |
|             | Hence smallest value of $n$ is <b>8</b>                                                                                                                                                                                                                                                               | B1cso             |
|             |                                                                                                                                                                                                                                                                                                       | <b>(10 marks)</b> |

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| Question    | Scheme                                                                                                                       | Marks             |
|-------------|------------------------------------------------------------------------------------------------------------------------------|-------------------|
| <b>3(a)</b> | $n$ is large and $p$ close to 0.5                                                                                            | B1B1              |
|             |                                                                                                                              | <b>(2)</b>        |
| <b>3(b)</b> | There would be no pea seeds left                                                                                             | B1                |
|             |                                                                                                                              | <b>(1)</b>        |
| <b>3(c)</b> | $H_0: p = 0.55$ $H_1: p \neq 0.55$                                                                                           | B1                |
|             |                                                                                                                              | <b>(1)</b>        |
|             | $X \sim N(121, 54.45)$                                                                                                       | B1                |
|             | $P(X \geq 134.5) = P\left(Z \geq \frac{134.5 - 121}{\sqrt{54.45}}\right)$ or $\pm \frac{x - 0.5 - 121}{\sqrt{54.45}} = 1.96$ | M1M1A1            |
|             | $= P(Z \geq 1.8295..)$                                                                                                       |                   |
|             | $= 1 - 0.9664$                                                                                                               |                   |
|             | $= 0.0336/0.0337$ $x = 135.96$                                                                                               | A1                |
|             | Accept $H_0$ not in CR, not significant                                                                                      | M1                |
|             | The <u>company's claim</u> is justified or <u>55%</u> of its pea <u>seeds germinate</u>                                      | A1cso             |
|             |                                                                                                                              | <b>(7)</b>        |
|             | <u><b>Alternative</b></u>                                                                                                    |                   |
|             | $X \sim N(99, 54.45)$                                                                                                        | B1                |
|             | $P(X \leq 85) = P\left(Z \leq \frac{85.5 - 99}{\sqrt{54.45}}\right)$ or $\pm \frac{x + 0.5 - 99}{\sqrt{54.45}} = 1.96$       | M1 M1 A1          |
|             | $= P(Z \geq 1.8295..)$                                                                                                       |                   |
|             | $= 1 - 0.9664$                                                                                                               |                   |
|             | $= 0.0336/0.0337$ $x = 107.5$                                                                                                |                   |
|             |                                                                                                                              |                   |
|             | Accept $H_0$ not in CR, not significant                                                                                      | M1                |
|             | The <u>company's claim</u> is justified or <u>55%</u> of its pea <u>seeds germinate</u>                                      | A1cso             |
|             |                                                                                                                              | <b>(11 marks)</b> |

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| Question | Scheme                                                                                           | Marks            |
|----------|--------------------------------------------------------------------------------------------------|------------------|
| <b>4</b> | $X \sim N(40, 3^2) \quad \bar{X} \sim N(40, \frac{9}{n})$ (Condone $Y \sim N(40, \frac{9}{n})$ ) | B1               |
|          | $P(\bar{X} > 42) = P(Z > \frac{42 - 40}{\sqrt{\frac{9}{n}}})$                                    | M1               |
|          | $\frac{42 - 40}{\sqrt{\frac{9}{n}}} \geq 1.6449$                                                 | B1<br>dM1        |
|          | $n \geq 6.087$                                                                                   |                  |
|          | $n = 7$                                                                                          | A1               |
|          |                                                                                                  | <b>(5 marks)</b> |

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| Question    | Scheme                                                                                                                                                                                                       | Marks             |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| <b>5(a)</b> | $z = \pm 3.2905$                                                                                                                                                                                             | B1                |
|             | $\sigma = \frac{30}{3.2905}$                                                                                                                                                                                 | M1                |
|             | $\sigma = 9.117$ **                                                                                                                                                                                          | A1 cso            |
|             |                                                                                                                                                                                                              | <b>(3)</b>        |
| <b>5(b)</b> | $H_0 : \mu = 1000 \quad H_1 : \mu < 1000$                                                                                                                                                                    | B1                |
|             | mean weight = 999.54                                                                                                                                                                                         | B1                |
|             | $z = \frac{\bar{x} - \mu}{\frac{\sigma}{\sqrt{n}}} = \frac{(999.54 - 1000)}{\frac{9.117}{\sqrt{10}}} = -0.160 \quad \text{or}$ $\frac{c - 1000}{\sqrt{83.12/10}} = -2.3263 \therefore \text{CR } c < 993.29$ | M1A1              |
|             | 1% critical value = $-2.3263$                                                                                                                                                                                | B1                |
|             | $-2.3263 < -0.160$                                                                                                                                                                                           |                   |
|             | Accept $H_0$ / not in critical region                                                                                                                                                                        | dM1               |
|             | There is no evidence that that the machine is delivering packets of mean weight less than 1 kg                                                                                                               | A1ft              |
|             |                                                                                                                                                                                                              | <b>(7)</b>        |
|             |                                                                                                                                                                                                              | <b>(10 marks)</b> |

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|   | Source paper | Question number | New spec references       | Question description                       | New AOs                             |
|---|--------------|-----------------|---------------------------|--------------------------------------------|-------------------------------------|
| 1 | S2 2011      | 6               | A 4.1, 4.2, 5.1, 5.2, 5.3 | Binomial distribution, Normal distribution | 1.1b, 2.2b, 2.5, 3.3, 3.5a          |
| 2 | S2 Jan 2013  | 6               | A 5.1, 5.2                | Hypothesis testing, Tests on binomial      | 1.1b, 1.2, 2.5, 3.3, 3.5a           |
| 3 | S2 2014      | 5               | A 4.1, 4.2, 5.1, 5.3      | Continuous distributions, Hypothesis tests | 1.1b, 1.2, 2.2b, 2.4, 2.5, 3.3, 3.4 |
| 4 | S3 2013R     | 2               | A 5.3                     | Tests on normal mean                       | 1.1b, 2.1, 3.1b, 3.4                |
| 5 | S3 2014      | 7               | A 5.3                     | Tests on normal mean                       | 1.1b, 2.1, 2.2b, 2.5, 3.1b, 3.4     |