Qu 3	Scheme	Marks	AO
(a)	Hectopascal or hPa	B1 **(1)**	1.2
(b)	$\bar{x} = \bar{y} + 1010$ or $\frac{214}{30} + 1010$	M1	1.1b
	= 1017.1333… awrt **1017**	A1 **(2)**	1.1b
(c)	$\sigma_x = \sigma_y$ (or statement that standard deviation is not affected by this type of coding)	M1	3.1b
	$\left[\sigma_y =\right] \sqrt{\frac{5912}{30} - (\text{"7.13[33...]"})^2}$ or $\sqrt{146.1822...}$	M1	1.1b
	= 12.0905… awrt **12.1**	A1 **(3)**	1.1b
(d)	High pressure (since approx. mean + sd) so clockwise Locations are (from North to South): Leuchars, Heathrow, Hurn	B1	2.4
	Wind direction is direction wind blows from So: Heathrow (**NE**) Hurn (**E**) Leuchars (**W**)	B1 **(2)**	2.2a
		(8 marks)	

	Notes
FYI	1 hPa = 100 Pa; 10hPa = 1 kPa; 1Pa = 1 Nm^{-2}
(a)	B1 for "hectopascal" or hPa (condone pascals, allow millibars or mb) o.e. Do NOT allow kPa or kilopascals or Pa on its own
(b)	M1 for a strategy to find $\bar{x}$ Allow an attempt to find $\sum x$ that gets as far as $\sum x = \sum y + 30 \times 1010$ [= 30 514] A1 for awrt 1017 (accept 1020) [Ignore incorrect units]
(c)	1st M1 for an overall strategy using the fact $\sigma_x = \sigma_y$ (can be implied by correct final ans) or for $\sum x = 30\,514$ and $\sum x^2 = 31\,041\,192$ (both seen and correct) 2nd M1 for a correct expression (with $\sqrt{}$)(ft their $\bar{y}$ to 3sf) allow awrt 146 for 146.1822.. or for correct expression in x can ft their $\sum x > 30\,000$ or their answer to (b) A1 (dep on 2nd M1) for awrt 12.1 [Ignore incorrect units]
Final answer	Final ans of awrt 12.1 scores 3/3 **but** if they then adjust for x e.g. add 1010 (M0M1A1)
(d)	1st B1 for at least one of these reasons (these 2 lines) clearly stated (may see diagram) Need "high pressure" **and** "clockwise" to score on 1st line Contradictory statements B0 e.g. correct N~S list but say "anticlockwise" 2nd B1 (indep of 1st B1) for deducing the 3 correct directions either in the table or stated as above If the answers in table and text are different we take the table (as question says)

Section A: STATISTICS

<table>
<tr><th>Qu 1</th><th>Scheme</th><th>Marks</th><th>AO</th></tr>
<tr><td>(a)</td><td>
<table>
<tr><td>c</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr>
<tr><td>P($C = c$)</td><td>$\frac{1}{9}$</td><td>$\frac{1}{9}$</td><td>$\frac{1}{9}$</td><td>$\frac{1}{9}$</td><td>$\frac{1}{9}$</td><td>$\frac{1}{9}$</td><td>$\frac{1}{9}$</td><td>$\frac{1}{9}$</td><td>$\frac{1}{9}$</td></tr>
</table>
</td><td>B1
B1ft
(2)</td><td>1.2
1.2</td></tr>
<tr><td>(b)</td><td>P($C < 4$) = $\frac{4}{9}$ (accept 0.444 or better)</td><td>B1
(1)</td><td>3.4</td></tr>
<tr><td>(c)</td><td>Probability lower than expected suggests model is <u>not</u> good</td><td>B1ft
(1)</td><td>3.5a</td></tr>
<tr><td>(d)</td><td>e.g. Cloud cover will vary from month to month and place to place
So e.g. use a non-uniform distribution</td><td>B1
(1)</td><td>3.5c</td></tr>
<tr><td></td><td></td><td colspan="2">(5 marks)</td></tr>
<tr><td></td><td colspan="3">Notes</td></tr>
<tr><td>(a)</td><td colspan="3">1st B1 for a correct set of values for c. Allow $\{\frac{1}{8}, \frac{2}{8}, \ldots \frac{8}{8}\}$
2nd B1ft for correct probs from their values for c, consistent with discrete uniform distrib'n
Maybe as a prob. function. Allow P($X = x$) = $\frac{1}{9}$ for $0 \leqslant x \leqslant 8$ provided x = {0, 1, 2, …, 8} is clearly defined somewhere.</td></tr>
<tr><td>(b)</td><td colspan="3">B1 for using correct model to get $\frac{4}{9}$ (o.e.)</td></tr>
<tr><td>SC</td><td colspan="3">Sample space {1, …, 8} If scored B0B1 in (a) for this allow P($C < 4$) = $\frac{3}{8}$ to score B1 in (b)</td></tr>
<tr><td>(c)</td><td colspan="3">B1ft for comment that states that the model proposed is or is not a good one based on their model in part (a) and their probability in (b)
|(b) – 0.315| > 0.05 Allow e.g. "it is not suitable"; "it is not accurate" etc
|(b) – 0.315| ⩽ 0.05 Allow a comment that suggests it <u>is</u> suitable
No prob in (b) Allow a comparison that mentions 50% or 0.5 and rejects the model
No prob in (b) and no 50% or 0.5 or (b) > 1 scores B0
Ignore any comments about location or weather patterns.</td></tr>
<tr><td>(d)</td><td colspan="3">B1 for a sensible refinement considering variations in month or location
Just saying "not uniform" is B0
Context & "non-uniform" Allow mention of different locations, months <u>and</u> non-uniform
<u>or</u> use more locations to form a new distribution with probabilities based on frequencies
Context & "binomial" Allow mention of different locations, months <u>and</u> binomial
Just refined model Model must be outlined and discrete and non-uniform
e.g. higher probabilities for more cloud cover <u>or</u> lower probabilities for less cloud cover
Continuous model Any model that is based on a continuous distribution. e.g. normal is B0</td></tr>
</table>

Question	Scheme	Marks	AOs
2(a)	IQR = 26.6 – 19.4 [= 7.2]	B1	2.1
	19.4 – 1.5 × '7.2' [= 8.6] or 26.6 + 1.5 × '7.2' [= 37.4]	M1	1.1b
	Plotting one upper whisker to 32.5 **and** one lower whisker to 8.6 or 9.1	A1	1.1b
	Plotting 7.6 and 8.1 as the only two outliers	A1	1.1b
		(4)	
(b)	October (since it is the month with the coldest temperatures between May and October in Beijing)	B1	2.4
		(1)	
(c)	$[\sigma =]\sqrt{\frac{4952.906}{184}}$ or e.g. $[\sigma =]\sqrt{\frac{S_{xx}}{n}} = 5.188...$ [=5.19*]	B1cso*	1.1b
		(1)	
(d)	$z = (\pm)\ 1.28(16)$ $[P_{90} =]29.251...$ or $[P_{10} =]15.948...$	B1	3.1b
	2 × 1.2816 × 5.19 '29.251…' – '15.948…'	M1	1.1b
	= awrt **13.3**	A1	1.1b
		(3)	
(e)	Daily mean wind speed/Beaufort conversion since it is qualitative Rainfall since it is not symmetric/lots of days with 0 rainfall	B1 B1	2.4 2.4
		(2)	
			(11 marks)

Notes

(a)

B1: for a correct calculation for the IQR (implied by 10.8 **or** 8.6 **or** 37.4 seen)
M1: for a complete method for either lower outlier limit or upper outlier limit (allow ft on their IQR) (may be implied by the 1st A1 or a lower whisker at 8.6)
A1: both whiskers plotted correctly (allow ½ square tolerance)
A1: only two outliers plotted, 7.6 and 8.1 (must be disconnected from whisker)
NOTE: A fully correct box plot with no incorrect working scores 4/4

(c)

B1cso*: Correct expression with square root **or** correct formula and 5.188 or better
Allow a complete correct method finding $\sum x^2 =$ awrt 98720 and $\sigma = \sqrt{\frac{98715.9...}{184} - \left(\frac{4153.6}{184}\right)^2}$

(d)

B1: Identifying z-value for 10th or 90th percentile (allow awrt (±) 1.28)
or for identifying $[P_{90} =]29.251...$ (awrt 29.3) or $[P_{10} =]15.948...$ (awrt 15.9)
(This may be implied by a correct answer awrt 13.3)
M1: for $2 \times z \times 5.19$ where $1 < z < 2$
or for their $P_{90} - P_{10}$ where $25 < P_{90} < 35$ and $10 < P_{10} < 20$
A1: awrt 13.3

(e)

B1: for one variable identified and a correct supporting reason
B1: for two variables identified and a correct supporting reason for each
Allow any two of the following:

- Wind speed/Beaufort since the data is non-numeric (o.e.). They need not mention Beaufort provided there is a description of the data as non-numeric (Do not allow wind direction/wind gust)
- Rainfall as not symmetric/is skewed/is not bell shaped/lots of 0s /many days with no rain/mean≠mode or median
- Date since each data value appears once/it is uniformly distributed
- Daily mean pressure since it is not symmetric/is skewed/not bell shaped
- Daily mean wind speed since it is not symmetric/is skewed/not bell shaped

Do not allow 'not continuous' or 'discrete' as a supporting reason.
Ignore extraneous non-contradicting statements

Question	Scheme	Marks	AOs
4 (a)	$\frac{132}{184} = 0.71739...$ awrt **0.717**	B1	1.1b
		(1)	
(b)(i)	$P(X \geq 6) = 1 - P(X \leq 5)$ or $P([X =]6) + P([X =]7) + P([X =]8)$	M1	3.4
	$= 1 - 0.296722...$ awrt **0.703**	A1	1.1b
		(2)	
(b)(ii)	$184 \times P(X = 7)$ $[= 184 \times 0.2811\ldots]$	M1	1.1b
	$= 51.7385...$ awrt **51.7**	A1	1.1b
		(2)	
(c)	Part (a) and part (b)(i) are similar **and** the expected number of 7s (51.7 or 0.281) matches with the number of 7s found in the data set (52 or 0.283) so Magali's model is supported.	B1ft	3.5a
		(1)	
(d)	$\frac{23}{28} = 0.82142...$ awrt **0.821**	B1	1.1b
		(1)	
(e)	Any one of… • Part (d)/'0.821' differs from part (a)/(b)(i)/(0.7…) • there is a **greater/different probability of high cloud cover**/**more likely to have high cloud cover** if the previous day had high cloud cover • **independence(o.e.)** does not hold	B1	2.4
	…therefore Magali's (binomial) model may not be suitable.	dB1	3.5a
		(2)	
			(9 marks)

Notes	
	Allow fractions, decimals or percentages throughout this question.
(a)	Allow equivalent fraction, e.g. $\frac{33}{46}$
(b)(i)	**M1:** for writing or using $1 - P(X \leq 5)$ or $P(X = 6) + P(X = 7) + P(X = 8)$ **A1:** awrt 0.703 (correct answer scores 2 out of 2)
(b)(ii)	**M1:** for $184 \times P(X = 7)$ o.e. e.g., $184 \times [P(X \leq 7) - P(X \leq 6)]$ **A1:** awrt 51.7
(c)	**B1ft:** comparing '0.717' with '0.703' and '51.7 or '0.281' with 52 or 0.283 **and** concluding that Magali's model **is supported** (must be comparing prob. with prob. and days with days). Allow not supported or mixed conclusions if consistent with their f.t. answers in (a) and (b)
(e)	**B1:** Any bullet point **dB1:** (dep on previous B1) for Magali's model may not be suitable (o.e.) Condone not accurate for not suitable **SC:** part (d) is similar to part (a)/(b)(i) **and** a compatible conclusion (i.e. Magali's model is supported) to score B1B1.

Qu 2	Scheme	Marks	AO
(a)	Negative	B1 **(1)**	1.2
(b)(i)	Rainfall	B1	2.2b
(ii)	mm <u>or</u> Pressure hPa or Pascals or hectopascals or mb or millibars	B1ft **(2)**	1.1b
(c)	$H_0 : \rho = 0$ $H_1 : \rho \neq 0$	B1	2.5
	Critical value: $-0.361(0)$	M1	1.1b
	$r < -0.3610$ so significant result and there is evidence of a correlation between Daily Total <u>Sunshine</u> and Daily Maximum Relative <u>Humidity</u>	A1 **(3)**	2.2b
(d)	Humidity is high and there is evidence of correlation and $r < 0$ So expect amount of sunshine to be <u>lower</u> than the <u>average</u> for Heathrow(oe)	B1 **(1)**	2.2b
		(7 marks)	

	Notes
(a)	B1 for stating negative. "Negative skew" is B0 though
(b)(i)	B1 for mentioning "rainfall" (allow "rain" <u>or</u> "precipitation") <u>or</u> "pressure" (if more than 1 answer both must be correct) NB the other quantitative variable for Perth is: Daily Mean Wind Speed and scores B0 [Not allowed "wind speed" since $r = +0.15$ and in winter might expect wind to raise temp]
(ii)	B1ft for giving the correct units. If Daily Mean Wind Speed (kn) or knots "Wind speed" and "knots" would score B0B1 but any other variable scores B0B0
(c)	B1 for both hypotheses correct in terms of ρ M1 for the correct critical value compatible with their H_1: allow $\pm$ 0.361(0) If the hypotheses are 1-tail then allow cv of $\pm$ 0.3061 e.g. Alternative hypothesis with $r < \pm$ 0.377 implies a one-tail test <u>or</u> H_0 and H_1 in words saying "H_0: there is no correlation, H_1: there is correlation" is two-tail If there are no hypotheses (or they are nonsensical) assume 2-tail so M1 for $\pm$ 0.361(0) A1 for a correct conclusion in context based on comparing -0.377 with their cv. Condone incorrect inequality e.g. $-0.3610 < -0.377$ as long as they reject H_0 Do not accept contradictory statements such as "accept H_0 so there is evidence of …" Can say "support for Stav's <u>belief</u>"(o.e.e.g. "claim") or "evidence of a correlation between <u>sunshine</u> and <u>humidity</u>" condone "negative correlation" or comments such as "if humidity is high amount of sunshine will be low"
(d)	B1 for stating <u>low</u> amount of sunshine (o. e.) **and** some reference to $r < 0$ or fog Check for the following 2 features: (i) **low** sunshine: allow $\leqslant$ 5 hrs (LDS mean for 2015 is 5.3, humidity 97% is 4.1, $\geqslant$ 97% is 3.1) (ii) **negative** correlation may be described in words e.g. "high humidity gives low sunshine" <u>or</u> **fog** (LDS says >95% humidity is foggy) so less sunshine

Paper 3: Statistics and Mechanics Mark Scheme

Question	Scheme	Marks	AOs
1(a)	**Area** = $8\times1.5=12$ cm^2 **Frequency** = 8 so 1 cm^2 = $\frac{2}{3}$ **hour (o.e.)**	M1	3.1a
	Frequency of 12 corresponds to area of 18 so height = $18\div2.5$ = **7.2 (cm)**	A1	1.1b
	Width = 5×0.5 = **2.5 (cm)**	B1cao	1.1b
		(3)	
(b)	$[\bar{y}=]\ \frac{205.5}{31}=$ awrt 6.63	B1cao	1.1b
	$\left[\sigma_y=\right]\sqrt{\frac{1785.25}{31}-\bar{y}^2}$ = $\sqrt{13.644641}$ = **awrt 3.69** allow $[s=]\sqrt{\frac{1785.25-31\bar{y}^2}{30}}$ = **awrt 3.75**	M1 A1	1.1a 1.1b
		(3)	
(c)	Mean of Heathrow is higher than Hurn and standard deviation smaller suggesting Heathrow is more reliable	M1	2.4
	Hurn is South of Heathrow so does <u>not</u> support his belief	A1	2.2b
		(2)	
(d)	$\bar{x}+\sigma\approx10.3$ so number of days is e.g. $\frac{(11-"10.3")}{3}\times8\ (+5)$	M1	1.1b
	= 6.86 so **7 days**	A1	1.1b
		(2)	
(e)	[H = no. of hours] P(H > 10.3) or P(Z > 1) = [0.15865…]	M1	3.4
	Predict $31\times0.15865...$ = **<u>4.9 or 5 days</u>**	A1	1.1b
		(2)	
(f)	(5 or) 4.9 days < (7 or) 6.9 days so model may **not** be suitable	B1	3.5a
		(1)	
			(13 marks)

Question	Scheme	Marks	AOs
2(a)	e.g. It requires extrapolation so will be unreliable (o.e.)	B1	1.2
		(1)	
(b)	e.g. Linear association between w and t	B1	1.2
		(1)	
(c)	H_0: $\rho = 0$ H_1: $\rho > 0$	B1	2.5
	Critical value 0.5822	M1	1.1a
	Reject H_0		
	There is evidence that the product moment correlation coefficient is greater than 0	A1	2.2b
		(3)	
(d)	Higher $\bar{t}$ suggests overseas and not Perth…lower wind speed so perhaps not close to the sea so suggest **Beijing**	B1	2.4
		(1)	
			(6 marks)

Notes:

(a)
B1: for a correct statement (unreliable) with a suitable reason

(b)
B1: for a correct statement

(c)
B1: for both hypotheses in terms of ρ
M1: for selecting a suitable 5% critical value compatible with their H_1
A1: for a correct conclusion stated

(d)
B1: for suggesting Beijing with some supporting reason based on t or w
Allow Jacksonville with a reason based just on higher $\bar{t}$