Wilcoxon Rank-Sum Tests (From OCR 4735)

Q1, (Jun 2008, Q4)

(ii)	$H_0: m_M = m_A$, $H_1: m_M \neq m_A$		B1	Both hypotheses, AEF. Not "average"
	$R_m = 40$, $m(m+n+1) - R_m = 72$		M1	Both found
	$W = 40$		A1	A0 if no or wrong 72
	CR: $W \leq 38$		B1	
	40 not in CR, so do not reject H_0		M1	Or equivalent
	Insufficient evidence that median times differ	A1	**6 (7)**	In context. B1 if no M1 but conclusion correct Allow average here

Q2, (Jun 2011, Q5)

(i)	Does not require a known probability distribution	B1 **1**	Or equivalent
(ii)	$H_0: m_A = m_B$, $H_1: m_A \neq m_B$	B1	Medians
	Ranks: A 1 2 3 5 6 10		
	B 4 7 8 9 11 12	M1	
	$R_A = 27$, $78 - 27 = 51$, so $W = 27$	M1	
	OR: $R_B = 51$, $78 - 51 = 27$	A1	
	5% CV = 26	B1	Use N(39,39) with cc B1
	27 > CV so do not reject H_0	M1	P(W≤27.5), Z=-1.84 or equivalent M1
	there is insufficient evidence at the 5% SL to indicate a difference in breaking strengths	A1 **7**	Not in CR etc A1
(iii)	*B* would have an extra rank 13	M1	
	W still 27 but CV now 27	B1	P(W≤27.5)=-2.07 M1A1
	H_0 is now rejected	A1 **3** **[11]**	In CR Ho rejected A1

Q3, (Jun 2014, Q6)

(i)		$1 + 2 + \ldots + 11$ $= 66$	M1 A1 **[2]**	M0 if followed by incorrect work.	
(ii)		(N) (132,264) $\frac{(W + 0.5 - "132")}{\sqrt{"264"}}$ $< -$ 2.576 Solve inequality < 89.6 $(66 \leq) W \leq 89$	B1 M1 M1* B1 *M1 A1 **[6]**	Allow wrong, or no, cc. May be earned later. Allow 2.58 or equation if final answer uses < or ≤ Integer needed.	Allow reversed if consistent OR 132(-0.5)±z×√264 M1 z=2.576 or 2.58 B1 (89.6,[173.4]) A1 < lower limit M1 ≤89 A1 Allow if lower limit only considered.

Q4, (Jun 2012, Q3i)

(i)	Populations have identical/same distributions (apart from location) (H_0: $m_1 = m_2$, H_1: $m_1 \neq m_2$) Ranks 1 2 4 6 9 10 3 5 7 8 11 12 13 $R_m = 32$, $m(m + n + 1) - R_m = 52$ $W = 32$ Critical value = 29 32 > 29, do not reject H There is insufficient evidence at the 10% significance level of a difference between the median marks of the two groups. oe.	B1 M1 A1 A1 B1 M1 A1 **[7]**	Allow 'Data quantitative' Can be implied. M1A0A1 possible Correct first conclusion ft TS and CV ft TS only.	Allow 'No assumption necessary' stated.

Q5, (Jun 2013, Q4)

(i)		Distribution of heights may not be normal/is unknown	B1 **[1]**	Allow "No assumption required", but nothing else Not "groups independent" unless something else as well
(ii)		H_0: $m_A = m_B$, H_1: $m_A \neq m_B$	B1	Medians. Allow words in context. Not μ unless "median" stated
		Ranks: A: 4, 8, 10, 11, 14, 15, 16, 18, 20, 21, 22 B: 1, 2, 3, 5, 6, 7, 9, 12, 13, 17, 19	B1	
		$m = n = 11$, $R_m = 159$ or 94	B1	
		Use normal approximation with mean 126.5 [= 253/2]	M1	allow $\frac{1}{2}\times 11\times(11+11+1)$
		Variance 231.92 [= 2783/12]	B1	allow $\frac{1}{12}\times 11\times 11\times(11+11+1)$
		(α) $P(\leq 94) = \Phi((94.5 - 126.5)/\sqrt{(231.92)})$ or $P(\geq 159) = 0.0178$ < 0.025 and reject H_0	M1 A1 M1	Standardising. Allow no/incorrect cc. Value ft TS
		(β) $z = (94.5 - 126.5)/\sqrt{(231.92)} = -2.101$ < -1.96 so reject H_0	M1A1 M1	Standardising ; value ft TS
		There is evidence that salinity affects growth	A1 **[9]**	Or equivalent in context. ft TS.

Q6, (Jun 2015, Q6)

H0:The samples are drawn from identical popns. H1:The samples are from different popns.	B1	Allow $m_1=m_2$; $m_1\neq m_2$	Critical region method . First B1B1B1as main scheme $\frac{x+0.5-188.5}{\sqrt{471.25}}$ = or < -1.96 M1A1B1 x<146 A1 135 is in CR, rej H0 M1 Conclusion A1
Mean=188.5 Var=471.25	B1 B1	Allow 13x29/2 Allow 13x15x29/12	
$\frac{135+0.5-"188.5"}{\sqrt{471.25}}$ -2.44 CV=-1.96 TS<CV, reject H_0 Sufficient evidence that the samples were drawn from different populations.	M1A1 ft A1 B1 M1 A1 **[9]**	Allow M1A0 for missing or incorrect c.c. Allow -2.46 no c.c, -2.49 wrong c.c. Ft both TS,CV Not over-assertive. Cwo, allow from(-2.46 or -2.49	0.0073 (or 0.0069 or 0.0064) B1 pft< 2.5% (allow 5% for M1), rej H_0

Q7, (Jun 2016, Q2)

H_0: $m_A = m_B$, H_1: $m_B < m_A$	B1	For both. Allow any sensible hypotheses.	
Attempt ranks	M1		
15, 1, 6, 12, 11, 13, 14; 7, 9, 3, 10, 8, 2, 5, 4	A1		
$R_m = 72$	A1		
$W = 40$	A1		
CV = 41	B1		
"40" < 41 reject H_0	M1	Ft TS and CV.	
Evidence that treatment *B* is more effective.	A1 **[8]**	In context, not over-assertive. Cwo.	