1	$\pi \times 2.5^2 \times 15$ (= 93.75π = 294.5243...)		5	M1	for using the formula for volume of cylinder
	$21.5 = \frac{m}{"294.5243"}$			M1	for using $d = \frac{m}{v}$ with *their* intended volume v
	(m =) 21.5 × '294.5243...' (= 6332.272692)			M1	for rearranging for $m = d \times v$
	'6332.27269' ÷ 1000 × 5 (=31.661…) or '6332.27269' ÷ 6 ÷ 1000 (= 1.055…) or '6332.27269'× 5 **and** 30 × 1000 (=30 000) or 30 ÷ ('6332.27269' ÷ 1000) (= 4.7376…)			M1	for a correct calculation that would enable a conclusion to be made based on mass
		No and correct comparable figure(s)		A1	for No oe and (31.6 to 31.7 **or** 1.05 to 1.06 **or** 4.70 to 4.74) seen
					Total 5 marks

Alternative Mark Scheme for Q1					
1	$\pi \times 2.5^2 \times 15$ (= 93.75π = 294.5243...)		5	M1	for using the formula for volume of cylinder
	$21.5 = \frac{30000}{v}$ or $21.5 = \frac{30000 \div 5}{v}$			M1	for using $d = \frac{m}{v}$ with given d and m
	(v =) $\frac{30000}{21.5}$ (=1395.34…) or (v =) $\frac{30000}{21.5 \times 5}$ (=279.069…)			M1	for rearranging for $v = \frac{m}{d}$ for either one nugget, or all five nuggets.
	"1395.34" **and** "294.52" × 5 (= 1472.62) or "279.06" **and** "294.52"			M1	for correct calculations that would enable a conclusion to be made based on volumes
		No and correct comparable figure(s)		A1	awrt 3sf
					Total 6 marks

2	$\sqrt{\frac{300}{108}}$ **or** $\sqrt{\frac{108}{300}}$ **or** $\sqrt{\frac{25}{9}}$ oe **or** $\sqrt{\frac{9}{25}}$ oe **or** $\left(\frac{300}{108}\right)^3 = \left(\frac{V}{135}\right)^2$ oe			M1	for a correct linear scale factor (fraction or ratio) **or** for the use of $\left(\frac{A_1}{A_2}\right)^3 = \left(\frac{V_1}{V_2}\right)^2$
	$135 \times \left(\sqrt{\frac{300}{108}}\right)^3$ oe **or** $\sqrt{\frac{300^3}{108^3}} \times 135^2$ **or** $\sqrt{390625}$			M1	
		625	3	A1	
					Total 3 marks

3	$\pi \times 3^2 \times h = 72\pi$ oe			M1	Allow use of 3.14... or $\frac{22}{7}$ for π and use of 226... for 72π
	$h = 72\pi \div (\pi \times 3^2)$ oe **or** $h = 8$			M1	method to isolate h (may be seen in several stages)
	$2 \times \pi \times 3^2$ (= 18π or 56.54...) **or** $2 \times \pi \times 3 \times$ "8" oe (= 48π or 150 - 151)			M1	method to find the area of the two circles **or** curved surface area – use of their h, dep on 1st M1 (NB may get this mark for total area of 2 circles with no previous marks awarded)
	$2 \times \pi \times 3^2 + 2 \times \pi \times 3 \times$ "8" oe (= 66π)			M1	method to find total surface area ft their h dep on 1st M1, including intention to add, to find the total surface area
		207	5	A1	accept 207-208
					Total 5 marks

4	$\frac{1}{3}\times\pi\times r^2\times 2h\left(=\frac{2}{3}\pi r^2h\right)$ **OR** $\frac{1}{3}\times\pi\times(0.5r)^2\times h\left(=\frac{1}{12}\pi r^2h\right)$			M1	for finding the volume of the small or large cone
	$"\frac{2}{3}\pi r^2h" - "\frac{1}{12}\pi r^2h"\left(=\frac{7}{12}\pi r^2h\right)$			M1	(dep) method to find the volume of the frustum (condone missing brackets)
	$"\frac{2}{3}\pi r^2h" - "\frac{1}{12}\pi r^2h" = \frac{4\pi r^3}{3}$			M1	equating volume of frustum and sphere (must be correct including brackets)
	e.g. $\frac{7}{12}\pi r^2h = \frac{4\pi r^3}{3}$			M1	for a correct simplified formula (1 term on each side)
		$\frac{7}{16}h$	5	A1	accept 0.4375h
					Total 5 marks

5	$\frac{h}{2}\times(7+12)\times 10 = 608$ oe		3	M2	M1 for $\frac{h}{2}\times(7+12)\times 10$
		6.4		A1	
					Total 3 marks

6	(ASF =) $\frac{13^2}{9^2}$ or $\frac{9^2}{13^2}$		4	M1	Correct SF for area. Accept 1.44^2 (= 2.07 or 2.09) or better for ASF or 0.69^2 (= 0.47 or 0.48) or better for ASF
	eg $A + "(\frac{13^2}{9^2})" A = 1800$			M1ft	Dep on previous M1
	eg $"\frac{250}{81}" A = 1800$			M1ft	
		583.2		A1	Awrt 583
					Total 4 marks

7	$0.14 = \frac{56}{w^2}$ oe **or** $56 \div 0.14$ (= 400)		4	M1	for using the given formula correctly
	$\sqrt{\frac{56}{0.14}}$ **or** $\sqrt{'400'}$ (=20)			M1	for a method to find w
	'20' × '20' × '20' oe			M1	(dep on M2) for a method to find the volume of the cube
		8000		A1	
					Total 4 marks

8	$1600 = \frac{1}{3}\times\pi\times r^2\times 25$ oe		6	M1 for substituting into volume formula for cone correctly and equating to 1600
	eg $r = \sqrt{\frac{1600}{\frac{1}{3}\pi\times 25}}$ or $r = \sqrt{\frac{192}{\pi}}(=\sqrt{61.1(154..)} = 7.8176...)$			M1 dep for correct rearrangement of volume formula for r
	$l = \sqrt{"7.817..."^2 + 25^2}(=\sqrt{686.1154...} = 26.193...)$			M1 Dep on M2 correct method to find slant height of cone (radius of sector)
	$2\times\pi\times$ "7.817…" (= 49.1196…) **or** $\pi\times"7.817..."\times"26.193..."(=643.315...)$			M1 for using $C = 2\pi r$ oe using figures from correct method **or** for using $A = \pi rl$ using figures from correct method
	$"49.1196..." = 2\times\pi\times"26.193..."\times\frac{x}{360}$ **or** $"643.315..." = \pi\times"26.193..."^2\times\frac{x}{360}$			M1 for using arc length = $2\pi r\times\frac{x}{360}$ **or** for using area of sector = $\pi r^2\times\frac{x}{360}$
		107°		A1 for 107° - 108°
				Total 6 marks

9	$11.2^2 - 7.4^2$ (= 70.68) or $[x =]\cos^{-1}\left(\frac{7.4}{11.2}\right)$ (= 48.64...) or $[y =]\sin^{-1}\left(\frac{7.4}{11.2}\right)$ (= 41.35...) or $\sin^{-1}\left(\frac{7.4\sin 90}{11.2}\right)$		5	M1 A correct first stage to finding the perpendicular height of the triangular cross section
	eg $\sqrt{11.2^2 - 7.4^2}$ (= 8.407...) **or** $[h =]\sin"48.64..."\times 11.2$ **or** $\tan"48.64..."\times 7.4 (= 8.407...)$ **or** $[h =]\cos"41.35..."\times 11.2$ **or** $\frac{7.4}{\tan"41.35..."}$ (=8.407…)			M1 oe eg $h = \frac{11.2\sin"48.64..."}{\sin 90}$
	eg 7.4 × "8.407" ÷ 2 (= 31.10....) **or** 7.4 × "8.407" × 15 (= 933.19...)			M1 for method to find area of cross section **or** volume of cuboid
	eg "31.10" × 15 (= 466.59...) **or** "933.19" ÷ 2 (= 466.59...)			M1 complete method to find volume of the prism
	Working not required, so correct answer scores full marks (unless from obvious incorrect working)	467		A1 accept 466 – 467 SCB2 (if M0 awarded) for $0.5 \times 7.4 \times \sqrt{11.2^2 + 7.4^2} \times 15$ (= 745) **or** SCB1 (if M0 awarded) for $7.4 \times \sqrt{11.2^2 + 7.4^2} \times 15$ (= 1490) or $0.5 \times 7.4 \times \sqrt{11.2^2 + 7.4^2}$ (=49.6…) or 0.5 × 7.4 × 11.2 × 15 (= 621.6) or 622
				Total 5 marks

10	a	(*x* =) 270 ÷ (12 × 5) (= 4.5) oe		3	M1
		$\pi \times$ '4.5'$^2 \times 2 \times$ '4.5' (= 182.25π oe)			M1 ft dep on M1
			573		A1 accept 572 – 573
	b		1 000 000	1	B1 or (1 ×) 10^6 or (one or 1) million oe
					Total 4 marks

11	e.g. 30 × 20 × 125 (= 75 000) **or** 85 × 40 × 125 (= 425 000) **or** $(60\times 30 + (85-30)\times 40)\times 125 (= 500\ 000)$ oe		4	M1 for a method to find the volume of water already pumped out **or** the volume of water left **or** the total volume of the container
	"75 000" ÷ 1.5 (= 50 000) **or** "75 000" ÷ 90 (= 833.3... or $\frac{2500}{3}$) **or** "425000"÷"75000"(= 5.66... or $\frac{17}{3}$) **or** "500000"÷"75000"(= 6.66... or $\frac{20}{3}$)			M1 M2 for $\frac{"425000"}{"75000"} \times 1.5$ oe (= 8.5) **or** $\frac{"500000"}{"75000"} \times 1.5$ oe (= 10)
	"425 000" ÷ "50 000" (= 8.5) **or** "425 000" ÷ ("833.3..." × 60) oe (= 8.5) **or** "5.66…" × 1.5 (= 8.5) **or** "6.66…" × 1.5 (= 10)			M1
		20 30		A1 Allow 8 30 (pm)
				Total 4 marks

12	e.g. $(V =) \frac{1}{2}\left(\frac{4}{3}\pi x^3\right) + \pi x^2(20 - 4x)$ **or** $(V =) \frac{2}{3}\pi x^3 + 20\pi x^2 - 4\pi x^3$		5	M1 for a correct expression
	e.g. $\frac{1}{3}\pi y = \frac{1}{2}\left(\frac{4}{3}\pi x^3\right) + \pi x^2(20 - 4x)$ **or** $\frac{1}{3}\pi y = \frac{2}{3}\pi x^3 + 20\pi x^2 - 4\pi x^3$			M1 for a correct equation
	$y = 60x^2 - 10x^3$ oe			A1 for writing *y* in terms of *x*
	e.g. $\left(\frac{dy}{dx} =\right) 120x - 30x^2 = 0$ oe			M1 for differentiating their $ax^2 + bx^3$ and equating to 0
		320		A1 (dep on M3) cao
				Total 5 marks

13	(a)	$\left(\frac{37+28}{2}\right)\times 20 (=650)$		4	M1	Correct method to find area of trapezium
		$\sqrt{4.5^2+20^2}\,(=20.5)$ oe			M1	Correct method to find slanted edge AB oe
		2 × '650' + 2 × '20.5' × 24 + 37 × 24 + 28 × 24 (2 × '650' + 2 × 492 + 888 + 672)			M1	method to find the sum of the surface areas of at least 4 correct faces (ft their area of trapezium) ignore incorrect areas
			3844		A1	

14	eg $\frac{4}{3}\pi r^3 \div 2 (=\frac{2}{3}\pi r^3)$ oe		6	M1	for finding the volume of hemisphere
	eg $\frac{1}{3}\pi (kr)^2 kh \;-\; \frac{1}{3}\pi r^2 h (=\frac{1}{3}\pi r^2 h(k^3-1))$ oe			M1	for finding the volume of the frustum
	eg $\frac{1}{3}\pi r^2 h(k^3-1)+\frac{2}{3}\pi r^3$ **or** $\frac{1}{3}\pi r^2 h+\frac{2}{3}\pi r^3$ oe			M1	for a correct expression for the volume of Solid **A or** Solid **B**
	eg $\frac{1}{3}\pi r^2 h(k^3-1)+\frac{2}{3}\pi r^3 = 6\left(\frac{1}{3}\pi r^2 h+\frac{2}{3}\pi r^3\right)$ oe			M1	for a correct equation using the volumes of Solid **A** and Solid **B** (π could be cancelled out)
	eg $h(k^3-1)-6h=12r-2r$ oe			M1	for simplifying to a point where the h terms are on one side of an equation and other terms the other side – must be correct
	NB: note that simplest form was not required	$\frac{10r}{k^3-7}$		A1	oe eg $\frac{4r-\frac{2}{3}r}{\frac{1}{3}k^3-2\frac{1}{3}}$
					Total 6 marks

15	$580\pi = \pi \times 20 \times l$ oe		5	M1 for correct substitution into $A=\pi rl$
	$(l=)\frac{580\pi}{20\pi}\,(=29)$			M1
	$\sqrt{"29"^2-20^2}\;\left(=\sqrt{441}=21\right)$			M1
	$\left(\frac{1}{2}\times\frac{4}{3}\times\pi\times 20^3\right)+\left(\frac{1}{3}\times\pi\times 20^2\times "21"\right)$ or $\frac{16\,000}{3}\pi+\frac{8400}{3}\pi$ or $\frac{16\,000}{3}\pi+2800\pi$			M1 for a complete method (Award M4 for 8133.3…….. if $\frac{24\,400}{3}$ is not seen)
		$\frac{24\,400}{3}$		A1 $8133.\dot{3}$ or $8133\frac{1}{3}$ (as exact form was requested) SC B4 for an answer of 25551(.62….) if no method shown
				Total 5 marks

16			3	M1	For area of 2 different faces (ie not 2 triangles)
	0.5 × 4.8 × 3.6 (= 8.64) oe or 4.8 × 3.6 if clear intention for this to be 2 triangles 7 × 3.6 (= 25.2) 7 × 4.8 (= 33.6) 7 × 6 (= 42) **(all measurements with intention to add)**			M1	For adding together 5 areas , at least 4 of which are correct NB: (3.6 + 4.8 + 6) × 7 (= 100.8) is 3 faces
	Correct answer scores full marks (unless from obvious incorrect working)	118		A1	118.1 or 118.08
					Total 3 marks

17	eg $\pi \times 3^2 \times 7$ (= 63π or 197.9…)		3	M1	for method to find the volume of Solid **A**
	eg $\frac{2000}{[\text{vol A}]}$ **or** $\frac{3375}{450}\,(=7.5$ oe) **or** $\frac{2000+3375}{[\text{vol A}]+450}$			M1	(indep) for method to find the density of Solid **A**, **B** or **C,** allow use of their volume for Solids **A** and **C**
	Correct answer scores full marks (unless from obvious incorrect working)	8.3		A1	accept 8.29 – 8.31
					Total 3 marks

18	$\sqrt{\frac{3600}{625}}$ **or** $\frac{12}{5}$ oe **or** 2.4 **or** 12:5 oe **or** $\sqrt{\frac{625}{3600}}$ **or** $\frac{5}{12}$ oe **or** 0.416.... **or** 5:12 oe **or** $\frac{3600^3}{625^3}=\frac{(\text{vol of statue})^2}{750^2}$ oe **or** $\frac{3600}{625}=\frac{(\text{vol of statue})^{\frac{2}{3}}}{750^{\frac{2}{3}}}$ oe		3	M1	for a correct length scale factor **or** a correct length ratio **or** setting up a correct equation involving the volume of the statue
	eg $750\times\left("\frac{12}{5}"\right)^3$ oe **or** $750\div\left("\frac{5}{12}"\right)^3$ oe **or** $\sqrt{\frac{3600^3\times750^2}{625^3}}$ oe **or** $\left(\frac{3600\times750^{\frac{2}{3}}}{625}\right)^{\frac{3}{2}}$ oe			M1	(dep on M1) for a correct method to work out the volume of the statue
	Correct answer scores full marks (unless from obvious incorrect working)	10 368		A1	cao
					Total 3 marks

19	eg $k\times\frac{1}{3}\pi r^2h=\frac{4}{3}\pi r^3$ **or** $k\times\frac{1}{3}\pi r^2h=\frac{4}{3}\pi r^3$ **or** $k\times\frac{1}{3}\pi r^2h=\frac{4}{3}\pi r^3$ **or** $k\times h=4r$		6	M1	for setting up an equation with volumes and some simplification (minimum of 2 terms simplified)
	$h=\frac{4r}{k}$			M1	for finding h in terms of r and k in its simplest form (may be seen at a later stage)
	eg $l^2=r^2+\left(\frac{4r}{k}\right)^2$ **or** $l=\sqrt{r^2+\left(\frac{4r}{k}\right)^2}$			M1	for correct substitution into Pythagoras' theorem (accept substitution of $h=\frac{4\pi r}{\pi k}$)
	eg $l=r\sqrt{1+\frac{16}{k^2}}$ **or** $l=r\sqrt{\frac{k^2+16}{k^2}}$ **or** $l=r\frac{\sqrt{k^2+16}}{k}$			M1	for rearranging and removing the r from the square root (may be seen at a later stage)
	eg $\pi r^2\left(\sqrt{1+\frac{16}{k^2}}+1\right)$			M1	for a correct expression for surface area in terms of r and k with πr^2 removed as a factor
	Correct answer scores full marks (unless from obvious incorrect working)	$\pi r^2\left(\frac{k+\sqrt{k^2+16}}{k}\right)$		A1	
					Total 6 marks

20	$r=\sqrt{\frac{49\pi}{4\pi}}$ oe (= 3.5)		3	M1	
	[volume =] $\frac{4}{3}\times\pi\times"3.5"^3$			M1	
	Correct answer scores full marks (unless from obvious incorrect working)	180		A1	awrt 180
					Total 3 marks

21	$\sin 32 = \frac{(BC)}{50}$ or $\cos 32 = \frac{(CD)}{50}$ or $\frac{(BC)}{\sin 32} = \frac{50}{\sin 90}$ oe or $\frac{(CD)}{\sin(90-32)} = \frac{50}{\sin 90}$ oe		6	M1
	$(BC =) 50\sin 32 (= 26.4(959...))$ or $(BC =) \sqrt{50^2 - (50\cos 32)^2} (= 26.4(959...))$ or $(BC =) \sqrt{50^2 - "42.4..."^2} (= 26.4(998...))$ or $(BC =) \frac{50}{\sin 90} \times \sin 32$ oe			M1 for finding *BC* or *AD* Can be written on the diagram
	$(CD =) 50\cos 32 (= 42.4(024)\ldots)$ or $(CD =) \sqrt{50^2 - (50\sin 32)^2} (= 42.4(024...))$ or $(CD =) \sqrt{50^2 - "26.4..."^2} (= 42.4(622...))$ or $(CD =) \frac{50}{\sin 90} \times \sin(90-32)$			M1 for finding *CD* or *BA* Can be written on the diagram
	$(r =)$"42.4(024…)" ÷ 2π (= 6.74(855…))			M1 for finding the radius of the cylinder
	$(V =) \pi \times$ "6.74(855…)"$^2 \times$ "26.4(959…)"			M1 dep on previous M mark for the use of $\pi r^2 h$
	Correct answer scores full marks (unless from obvious incorrect working)	3790		A1 allow answers in the range 3737 – 3794 Accept answers in standard form
				Total 6 marks

22	$(39 \div 3)^2 + 39^2$ **or** 1521 + 169 (= 1690)		5	M1	for summing the area of the 2 squares – may be seen embedded in a calculation	
	$\sqrt{45^2 + (39 \div 2)^2}$ (= 49.043...) **or** $\sqrt{15^2 + \left(\frac{39 \div 3}{2}\right)^2}$ (= 16.347...) oe			M1	for finding the perpendicular slant height of either pyramid	M2 for eg $\sqrt{\left(\frac{39-13}{2}\right)^2 + (45-15)^2}$ $(= \sqrt{1069} = 32.695...)$
	$\frac{2}{3} \times$"49.043..." **or** 2×"16.347..." (= 32.695...) oe **OR** $\frac{1}{2} \times 13 \times$"16.347..."(= 106.260...) **or** $4 \times \frac{1}{2} \times 13 \times$"16.347..."(= 425.042...) **or** $\frac{1}{2} \times 39 \times$"49.043..."(= 956.345...) **or** $4 \times \frac{1}{2} \times 39 \times$"49.043..."(= 3825.381...)			M1	for finding the perpendicular slant height of the frustum **OR** the area of 1 or 4 triangular faces for either pyramid	
	$(39 \div 3)^2 + 39^2 + 4 \times \frac{(39 \div 3) + 39}{2} \times$ "32.695..." **OR** $(39 \div 3)^2 + 39^2 +$ "3825.381..." – "425.042..."			M1	correct calculation for total surface area	
	Correct answer scores full marks (unless from obvious incorrect working)	5090		A1	accept 5090 – 5091	
						Total 5 marks

23	$(x^2 =)\ \dfrac{13+6\sqrt{5}}{2\sqrt{5}-3}$		4	M1	expression for x^2
	$\dfrac{13+6\sqrt{5}}{2\sqrt{5}-3}\times\dfrac{2\sqrt{5}+3}{2\sqrt{5}+3}$ or $\dfrac{13+6\sqrt{5}}{2\sqrt{5}-3}\times\dfrac{-2\sqrt{5}-3}{-2\sqrt{5}-3}$			M1	dep on previous M1 showing a **correct** product to rationalise the denominator (must be correct x^2)
	eg $\dfrac{13+6\sqrt{5}}{2\sqrt{5}-3}\times\dfrac{2\sqrt{5}+3}{2\sqrt{5}+3}=\dfrac{99+44\sqrt{5}}{11}$ or eg $\dfrac{13+6\sqrt{5}}{2\sqrt{5}-3}\times\dfrac{2\sqrt{5}+3}{2\sqrt{5}+3}=\dfrac{26\sqrt{5}+39+60+18\sqrt{5}}{20-9}$ or eg $\dfrac{13+6\sqrt{5}}{2\sqrt{5}-3}\times\dfrac{2\sqrt{5}+3}{2\sqrt{5}+3}=\dfrac{26\sqrt{5}+39+12(\sqrt{5})^2+18\sqrt{5}}{(2\sqrt{5})^2-3^2}$			M1	dep on previous M1 continuing the expansion of the product on the numerator and denominator – maybe one of these forms or a combination of forms
	Working required	$2+\sqrt{5}$		A1	dep on M3 accept $a = 2$, $b = 5$
					Total 4 marks