1	$1600 = \frac{1}{3} \times \pi \times r^2 \times 25$ 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 $A = \pi r l$ 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

2		$[AM =] \sqrt{5^2 + 15^2} (= \sqrt{250} = 15.8...)$ where M is midpoint of EF, oe other correct method to find AM $[AD =] \sqrt{12^2 + 15^2} (= \sqrt{369} = 19.2...)$ $[DM =] \sqrt{12^2 - 5^2} (= \sqrt{119} = 10.9...)$		4	M2	for a complete method to find **two** of AM, AD, DM (where M is the midpoint of EF) Other longer ways to find AM, AD, DM may be used but must be a complete method eg $\angle DEM = \cos^{-1}(\frac{5}{12}) (= 65.37...)$ **and** $DM = 12 \sin 65.37...$ $\angle DEM = \cos^{-1}(\frac{5}{12}) (= 65.37...)$ **and** $DM = 5 \tan 65.37...$ Use 10 ÷ 2 as 5 throughout
					(M1	For a complete method to find **one** of AM, AD, DM (where M is the midpoint of EF))
		eg $\tan DAM = \frac{"\sqrt{119}"}{"\sqrt{250}"} \left(= \frac{"10.9..."}{"15.8..."}\right)$ oe **or** $\sin DAM = \frac{"\sqrt{119}"}{"\sqrt{369}"} \left(= \frac{"10.9..."}{"19.2..."}\right)$ oe **or** $\cos DAM = \frac{"\sqrt{250}"}{"\sqrt{369}"} \left(= \frac{"15.8..."}{"19.2..."}\right)$ oe			M1	a correct method to find the required angle –other longer methods may be used but they must get to the stage of an equation for the required angle eg $\sin DAM = \frac{"10.9..."}{\sqrt{"15.8..."^2 + "10.9..."^2}}$ NB: "10.9…" and "15.8…" must come from correct working
		Working not required, so correct answer scores full marks (unless from obvious incorrect working)	34.6		A1	any answer which rounds to 34.6
						Total 4 marks

3	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

4	$\sin\left(\frac{180-140}{2}\right)=\frac{MB}{8}$ oe or $\cos\left(\frac{140}{2}\right)=\frac{MB}{8}$ oe **or** $\frac{8}{\sin 20}=\frac{AC}{\sin 140}$ **and** $(MB^2)=8^2-\left(\frac{"15.035"}{2}\right)^2$ **or** $AC=\sqrt{8^2+8^2-2\times8\times8\times\cos140}$ (=15.035…) **and** $(MB^2)=8^2-\left(\frac{"15.035"}{2}\right)^2$		4	M1	for a correct expression with MB included, or an expression for MB^2 If using sine or cosine rule on the isosceles triangle ABC, use of Pythagoras required to obtain an expression for MB^2
	$(MB=)$ 8sin("20") (= 2.736) or $(MB=)$ 8cos("70") (= 2.736) or $(MB)=\sqrt{8^2-\left(\frac{"15.035"}{2}\right)^2}$			M1	
	$\tan TMB=\frac{10}{"2.736"}$			M1	dep 1st M1
		74.7		A1	74.65 to 74.75
					Total 4 marks

5	e.g. 30 × 20 × 125 (= 75 000) **or** 85 × 40 × 125 (= 425 000) **or** $(60\times30+(85-30)\times40)\times125$(= 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 $\frac{"425000"}{"75000"}\times1.5$ oe (= 8.5) **or** $\frac{"500000"}{"75000"}\times1.5$ 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

6	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

7	(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	
	(b)	eg $\sqrt{24^2+(37-"4.5")^2}\,(=40.4)$ $(AF=)\ \sqrt{24^2+20^2+(37-"4.5")^2}\ (=45.08...)$		3	M1	Correct method to find diagonal from A to point on HE below F **or** AF
		$\tan x=\frac{20}{"40.4"}$ or $\sin x=\frac{20(\sin 90)}{"45.08"}$ or $\cos x=\frac{"40.4"^2+"45.08"^2-20^2}{2\times"40.4"\times"45.08"}$			M1	Correct trig statement for finding the required angle
			26.3		A1	26.3 – 26.4
						Total 7 marks

8	eg $(BV^2=)3^2+6^2(=45)$ **or** $(CT^2=)3^2+6^2(=45)$ **or** $(DH^2=)\ 6^2+6^2\ (=72)$ **or** $(MV^2=)3^2+3^2(=18)$		4	M1	a correct expression for eg BV^2 **or** CT^2 **or** DH^2 **or** MV^2 where M is the midpoint of DC **or** a correct expression for [length]^2 for any length in the cube using Pythagoras	M3 for $(VT=)\sqrt{6^2+3^2+3^2}$ $(=3\sqrt{6}$ or 7.34...) (M2 for $(VT^2=)$ $6^2+3^2+3^2\,(=54)$)
	eg $(BV=)\sqrt{3^2+6^2}\ \left(=\sqrt{45}\text{ or }3\sqrt{5}\text{ or }6.70...\right)$ **or** $(CT=)\sqrt{3^2+6^2}\ \left(=\sqrt{45}\text{ or }3\sqrt{5}\text{ or }6.70...\right)$ **or** $(DH=)\sqrt{6^2+6^2}\ \left(=\sqrt{72}\text{ or }6\sqrt{2}\text{ or }8.48...\right)$ **or** $(MV=)\sqrt{3^2+3^2}\ \left(=\sqrt{18}\text{ or }3\sqrt{2}\text{ or }4.24...\right)$			M1	for a complete method for eg BV **or** CT **or** DH **or** MV **or** any length in the cube using Pythagoras	
	$(VT=)\ \sqrt{"45"+3^2}$ **or** $\sqrt{\left(\frac{"\sqrt{72}"}{2}\right)^2+6^2}$ **or** $\sqrt{"18"+6^2}$ **or** $3\sqrt{6}$ **or** 7.34...			M1	for a correct expression for VT (condone missing brackets around $3\sqrt{5}$ or $3\sqrt{2}$ or $\frac{\sqrt{72}}{2}$)	
		$\sqrt{54}$		A1	if $\sqrt{54}$ seen and answer then given as $3\sqrt{6}$ isw and award full marks	
						Total 4 marks

9	eg $\frac{4}{3}\pi r^3\div 2\left(=\frac{2}{3}\pi r^3\right)$ oe		6	M1	for finding the volume of hemisphere
	eg $\frac{1}{3}\pi(kr)^2kh\ -\ \frac{1}{3}\pi r^2h\left(=\frac{1}{3}\pi r^2h(k^3-1)\right)$ oe			M1	for finding the volume of the frustum
	eg $\frac{1}{3}\pi r^2h(k^3-1)+\frac{2}{3}\pi r^3$ **or** $\frac{1}{3}\pi r^2h+\frac{2}{3}\pi r^3$ oe			M1	for a correct expression for the volume of Solid **A** **or** Solid **B**
	eg $\frac{1}{3}\pi r^2h(k^3-1)+\frac{2}{3}\pi r^3=6\left(\frac{1}{3}\pi r^2h+\frac{2}{3}\pi r^3\right)$ 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

10	$580\pi = \pi \times 20 \times l$ oe		5	M1 for correct substitution into $A = \pi rl$
	$(l =)\dfrac{580\pi}{20\pi}(=29)$			M1
	$\sqrt{"29"^2 - 20^2}\ (=\sqrt{441} = 21)$			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

11	$\pi x^2 + 2\pi x\times 3x + \frac{1}{2}\times 4\pi x^2 = 81\pi$ oe or $9x^2 = 81$oe **or** $2\pi x\times 3x + \frac{1}{2}\times 4\pi x^2 = 81\pi$ oe or $8x^2 = 81$		6	M1 for setting up an equation (in a single variable ie x or r) for the total surface area of the shape **or** for the curved surface area.
	$(x =)\sqrt{\frac{81}{9}}(=3)$			M1 solving their equation in the form $kx^2\pi = 81\pi$ (where k follows correctly from their surface area) to find x
	$\pi\times'3'^2\times 3\times'3'+\frac{1}{2}\times\frac{4}{3}\pi'3'^3$ oe $(=81\pi + 18\pi = 99\pi = 311.(017\ldots))$			M1 (indep) for substituting their value of x to find the volume of the shape.
	99π or 311.(017…)			A1
	$\frac{840}{'311'}$ (= 2.7….) oe			M1 (dep on the 3rd M) for using the formula for density
		aluminium		A1 for aluminium **and** correct working leading to 2.7
				Total 6 marks

12			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

13	eg $k\times\frac{1}{3}\pi r^2 h = \frac{4}{3}\pi r^3$ **or** $k\times\frac{1}{3}\pi r^2 h = \frac{4}{3}\pi r^3$ **or** $k\times\frac{1}{3}\pi r^2 h = \frac{4}{3}\pi r^3$ **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

14	$r = \sqrt{\frac{49\pi}{4\pi}}$ 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