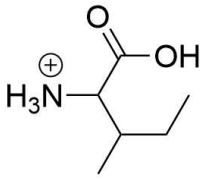
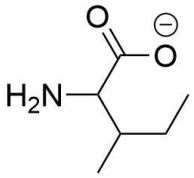
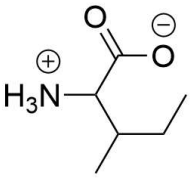
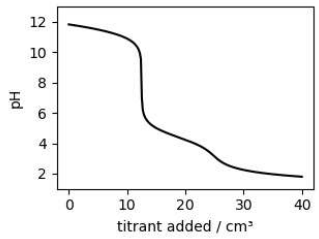
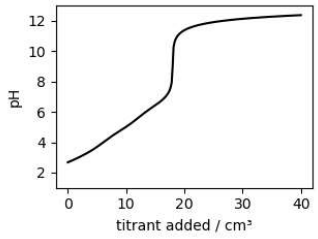
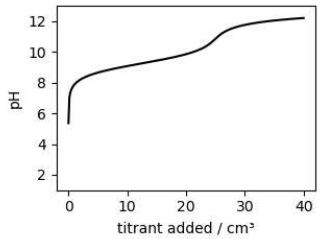
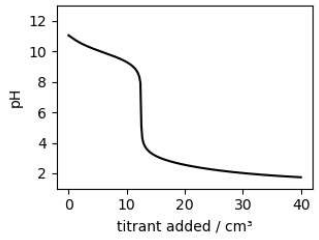
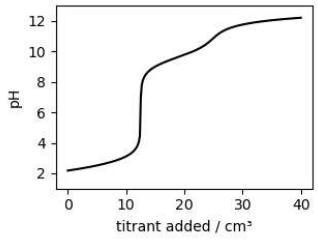
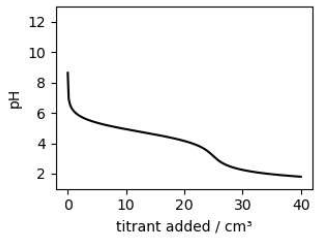
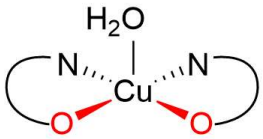
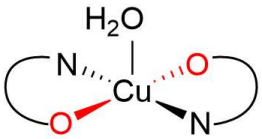
	(ii)	$B_2O_3 + 10N_2 + 3CaB_6 \rightarrow 20BN + 3CaO$ *State symbols not required. Accept any multiple with correct stoichiometry.*	☑
(h)	(i)	4.78×10^{-23} cm^3 $volume\ of\ cube = (side\ length)^3$ $v = a^3 = (3.63 \times 10^{-10}\ m)^3 = 4.78 \times 10^{-29}\ m^3 = 4.78 \times 10^{-23}\ cm^3$ *No marks for answer in m^3 or Å as question asked for cm^3.*	☑
	(ii)	3.45 g cm^{-3} Unit cell has 4 B and 4 N. (4 N completely within cube. $8 \times {}^1/_8$ B on corners, $6 \times {}^1/_2$ B on faces = 4 B). Mass of unit cell is $4(10.81+14.01)$ g mol^{-1} / 6.02×10^{23} mol^{-1} = 1.649×10^{-22} g Density (ρ) = mass (m) / volume (v) = 1.649×10^{-22} g / 4.78×10^{-23} cm^3 = 3.45 g cm^{-3} *Correct final answer scores full marks. First mark for correct number of B and N in unit cell. Second mark for correct mass of unit cell. Third mark for final answer. Allow ECF from part (h)(i).*	☑ ☑ ☑
	(iii)	3.74×10^{-23} cm^3 $area\ of\ regular\ hexagon = \frac{3\sqrt{3}}{2} \times (side\ length)^2$ area = $\frac{3\sqrt{3}}{2} \times (1.47 \times 10^{-10}\ m)^2 = 5.614 \times 10^{-20}\ m^2 = 5.614 \times 10^{-16}\ cm^2$ $volume\ of\ right\ prism = (area\ of\ base) \times (height)$ $v = 5.614 \times 10^{-16}\ cm^2 \times 6.66 \times 10^{-8}\ cm = 3.74 \times 10^{-23}\ cm^3$ *No marks for answer in m^3 or Å as question asked for cm^3.*	☑
	(iv)	2.20 g cm^{-3} Unit cell has 2 B and 2 N. ($6 \times {}^1/_6$ B on corners and $3 \times {}^1/_3$ B on edges, making total of 2). ($6 \times {}^1/_6$ N on corners and $3 \times {}^1/_3$ N on edges, making total of 2). Mass of unit cell is $2(10.81+14.01)$ g mol^{-1} / 6.02×10^{23} mol^{-1} = 8.246×10^{-23} g Density (ρ) = mass (m) / volume (v) = 8.246×10^{-23} g / 3.74×10^{-23} cm^3 = 2.20 g cm^{-3} *Correct final answer scores full marks. First mark for correct number of B and N in unit cell. Second mark for correct mass of unit cell. Third mark for final answer. Allow ECF from part (h)(iii).*	☑ ☑ ☑
	(v)	Unit cell has 2 B and 2 N. (1 B completely within unit cell, $4 \times {}^1/_{12}$ and $4 \times {}^2/_{12}$ B on corners, making total of 2). (1 N completely within unit cell, $2 \times {}^1/_6$ and $2 \times {}^2/_6$ N on edges, making total of 2). *Both must be correct for the mark.*	☑
		Total out of 20	**20**

3.	This question is about amino acid complexes	Mark
(a)	(i)  (ii) 	☑ ☑
	One mark each. If R group not drawn out or drawn out incorrectly, then one of the two marks can be awarded if protonation states correct in both structures.	
(b)	(i)  *No marks if R group not drawn out correctly.*	☑
	(ii) 5.98 Isoelectric point = (pK_{a1} + pK_{a2}) / 2 = (2.36 + 9.60) / 2 = 5.98	☑
(c)	     ✓ 	☑
	As base is being added, pH must rise over course of titration. Expect buffer zones (line flattens out) around the pH of the two pK_a values of 2.36 and 9.60.	

(d)



cis isomer

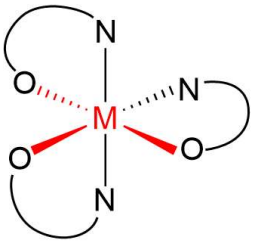


trans isomer

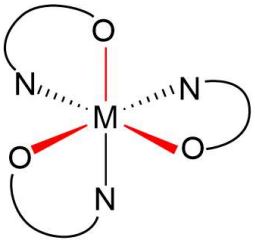
☑ ☑

One mark for cis isomer, one mark for trans isomer. If three complexes are drawn maximum mark is one out of two. If four complexes are drawn no marks should be awarded. Other views are acceptable, e.g. with linking chain at front and behind.

(e)



mer isomer



fac isomer

☑ ☑

One mark for mer isomer, this has the three O in the same meridian or plane of the metal ion. One mark for fac isomer, this has the three O on the same triangular face of the octahedron. If three complexes are drawn maximum mark is one out of two. If four complexes are drawn no marks should be awarded. Other views are acceptable, e.g. with linking chain at different positions.

(f)

$RhMt_3$

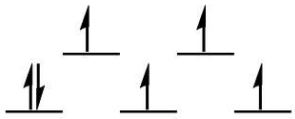
Number of d-electrons in outer shell

6

Arrangement 1

Spin magnetic moment, μ

0 BM



Arrangement 2

Spin magnetic moment, μ

4.90 BM = $2\sqrt{6}$ BM = $\sqrt{24}$ BM

☑ ☑ ☑ ☑

First mark for 6 d-electrons. Second mark for correct low spin arrangement. Third mark for correct high spin arrangement. Fourth mark for spin magnetic moments both correct. Student does not have to write 'low spin' or 'high spin'. Arrangements can be either way around. Do not penalise if units of BM missing. No ECF for spin magnetic moments based on incorrect orbital diagrams, or orbital diagrams based on incorrect number of d-electrons. No marks for arrangement if student draws two electrons with same spin in same orbital. All singularly filled orbitals must have parallel spins (all arrows pointing in same direction), otherwise no marks for arrangement. If singularly filled orbitals all have electrons pointing down this is also correct.