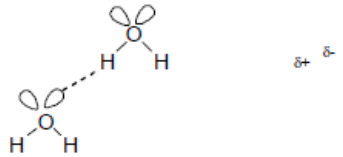
1)

Part	Sub Part	Marking Guidance	Mark	Comments
(a)	(i)	M_r = 132.1 0.0238	1 1	132 Allow 0.024 Allow 0.0237 Penalise less than 2 sig fig once in (a)
(a)	(ii)	0.0476	1	0.0474-0.0476 Allow (a) (i) x 2
(a)	(iii)	1.21	1	Allow consequential from (a) (ii) ie allow (a) (ii) x 1000 / 39.30 Ignore units even if wrong
(b)		$\frac{34 \times 100}{212.1}$ = 16.0(3)%	1 1	Allow mass or Mr of desired product times one hundred divided by total mass or Mr of reactants/products If 34/212.1 seen correctly award M1 Allow 16% 16 scores 2 marks
(c)		100(%)	1	Ignore all working
(d)		$PV = nRT$ or $n = \frac{PV}{RT}$ $n = \frac{100000 \times 1.53 \times 10^{-2}}{8.31 \times 310}$ = 0.59(4)	1 1 1	If rearranged incorrectly lose M1 and M3 M2 for mark for converting P and T into correct units in any expression Allow 0.593 M3 consequential on transcription error only not on incorrect P and T
(e)		(Na_2SO_4) (44.1%) H_2O 55.9% 44.1/142.1 = 0.310 =1 55.9/18 = 3.11 =10 x = 10	1 1 1	M1 is for 55.9 Alternative method gives180 for water part =2 marks X = 10 = 3 marks 10.02 = 2 marks

2)

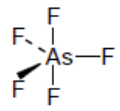
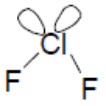
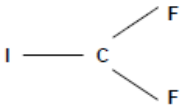
Part	Sub Part	Marking Guidance	Mark	Comments
(a)		Hydrogen/H bonds van der Waals/vdw/ dipole-dipole/London/temporarily induced dipole/dispersion forces	1 1	Not just hydrogen Not just dipole
(b)			3	M1 for partial charges as indicated in diagram (correct minimum) M2 for all four lone pairs M3 for H bond from the lp to the H (δ+) on the other molecule Lone pair on hydrogen CE = 0 OHO CE = 0 If only one molecule of water shown CE = 0
(c)		Hydrogen bonds/IMF (in water) stronger *OR* IMF / VDW / dipole-dipole forces (in H_2S) are weaker *OR* H bonding is the strongest IMF	1	Ignore energy references Comparison must be stated or implied
(d)		Atoms/molecules get larger/more shells/more electrons/ more surface area therefore increased Van der Waals/IMF forces	1 1	Not heavier/greater Mr Ignore references to dipole-dipole forces

(e)		Dative (covalent)/ coordinate	1	If not dative/coordinate CE = 0/2 If covalent or blank read on
		(Lone) pair/both electrons/two electrons on O(H_2) donated (to H^+) OR pair/both electrons come from O(H_2)	1	Explanation of a coordinate bond specific to oxygen or water required Not just H+ attracted to lone pair since that is nearer to a H bond
(f)		ionic	1	if not ionic CE = 0
		oppositely charged ions /+ and – ions or particles	1	atoms or molecules loses M2 and M3
		ions attract strongly OR strong/many (ionic) bonds must be broken	1	S^- loses M2 Reference to IMF loses M2 and M3

3)

Part	Sub Part	Marking Guidance	Mark	Comments
(a)		Average/mean mass of (1) atom(s) (of an element) 1/12 mass of one atom of ^{12}C *OR* (Average) mass of one mole of atoms 1/12 mass of one mole of ^{12}C *OR* (Weighted) average mass of all the isotopes 1/12 mass of one atom of ^{12}C *OR* Average mass of an atom/isotope compared to C-12 on a scale in which an atom of C-12 has a mass of 12	1 1 This expression = 2 marks	If moles and atoms mixes Max = 1
(b)		d block [Ar] $3d^24s^2$ 27	1 1 1	Allow 3d/D Other numbers lose M1 Ignore transition metals Can be written in full Allow subscripts $3d^2$ and $4s^2$ can be in either order
(c)		$\frac{(90x9) + (91x2) + (92x3)+ (94x3)}{17}$ (= 1550) (or ∑ their abundances) =91.2 Zr/ Zirconium	1 1 1 1	If one graph reading error lose M1 and allow consequential M2 and M3. If 2 GR errors penalise M1 and M2 but allow consequential M3 If not 17 or ∑ their abundances lose M2 and M3 91.2 = 3 marks provided working shown. M4 -allow nearest consequential element from M3 accept Zr in any circumstance
(d)		High energy electrons/bombarded or hit with electrons knocks out electron(s) (to form ions) Z^+ = 90 deflected most since lowest mass/lowest m/z	1 1 1 1	accept electron gun If not 90 lose M3 and M4 If charge is wrong on 90 isotope lose M3 only Accept any symbol in place of Z Allow lightest
(e)		(ions hit detector and) cause current/(ions) accept electrons/cause electron flow bigger current = more of that isotope/current proportional to abundance	1 1	QWC Implication that current depends on the number of ions

4)

Part	Sub Part	Marking Guidance	Mark	Comments
			1	**Mark M1 – M5 independently** M1 for 5 bond pairs around As Do not penalise A for As or Fl for F
		trigonal / triangular bipyramid(al)	1	Allow trigonal dipyramid
			1	M3 for 2 bond pairs to F and 2 lone pairs Lone pairs can be shown as lobes with or without electrons or as xx or x x
		Bent / V shape / non-linear / triangular / angular	1	Bent-linear = contradiction Do not allow trigonal
		104° - 106°	1	
		(For candidates who thought this was ClF_2^+ which contained iodine allow 		
		Trigonal / triangular planar		Not just triangular
		120°		

5)

estion	Marking Guidance		Mark	Comments
(a)	Method 1	Method 2		
	Mass of H_2O = 4.38-2.46 (= 1.92 g)	Percentage of H_2O = 44%	1	If there is an AE in M1 then can score M2 and M3 If M_r incorrect can only score M1
	$\frac{ZnSO_4}{161.5}$ $\frac{2.46}{}$ $\frac{H_2O}{18}$ $\frac{1.92}{}$ (0.0152 0.107) (1 : 7)	$\frac{ZnSO4}{161.5}$ $\frac{56}{}$ $\frac{H2O}{18}$ $\frac{44}{}$ (0.347 2.444) (1 : 7)	1	
	x = 7	x = 7	1	If x = 7 with working then award 3 marks. Allow alternative methods. If M1 incorrect due to AE, M3 must be an integer.
(b)	Moles HCl = 0.12(0)		1	
	mol $ZnCl_2$ = 0.06(0) *OR* 0.12 / 2		1	If M2 incorrect then CE and cannot score M2, M3 and M4.
	mass $ZnCl_2$ = 0.06 × 136.4		1	Allow 65.4 + (2 × 35.5) for 136.4
	= 8.18(4) (g) *OR* 8.2 (g)		1	Must be to 2 significant figures or more. Ignore units.

(c)	Moles $ZnCl_2$ = $\frac{10.7}{136.4}$ (= 0.0784) *OR* moles Zn = 0.0784 Mass Zn reacting = 0.0784 × 65.4 = (5.13 g) % purity of Zn = $\frac{5.13}{5.68}$ × 100 = 90.2% *OR* 90.3%	1 1 1 1	 M2 is for their M1 × 65.4 M3 is M2 × 100 / 5.68 provided M2 is < 5.68 Allow alternative methods. M1 = Moles $ZnCl_2$ = $\frac{10.7}{136.4}$ (= 0.0784) M2 = Theoretical moles Zn = $\frac{5.68}{65.4}$ (= 0.0869) M3 = M1 × 100 / M2 = (0.0784 × 100 / 0.0869) M4 = 90.2% *OR* 90.3%
(d)	Ionic Strong (electrostatic) attraction (between ions) between oppositely charged ions / + and – ions / F^- and Zn^{2+} ions	1 1 1	If not ionic CE = 0/3 If IMF, molecules, metallic bonding implied CE = 0/3

6)

Question	Marking Guidance	Mark	Comments
(a)	**M1** The activation energy is the minimum / least / lowest energy **M2** (energy) for a reaction to occur / to go / to start OR (energy) for a successful / effective collision	2	Mark independently Ignore "heat" and ignore "enthalpy" Ignore "breaking the bonds"
(b)	**M1** Catalysts provide an alternative route OR an alternative mechanism OR alternative / different path(way) **M2** Lowers the activation energy	2	Mark independently Ignore reference to "surface"
(c)(i)	Stay(s) the same	1	
(c)(ii)	Increases	1	Credit "increase" or "increased"
(c)(iii)	Increases	1	Credit "increase" or "increased"
(c)(iv)	Stay(s) the same	1	
(d)(i)	**M1** yeast or zymase **M2** ethanol	2	Ignore "enzyme" In M2, ignore "alcohol" and ignore any formula
(d)(ii)	**M1** (Concentrated) H_3PO_4 OR (Concentrated) H_2SO_4 **M2** butan-2-ol	2	Credit correct names Ignore "hydrogenphosphate or hydrogensulfate" Ignore "dilute" or "aq" Do not penalise absence of hyphens in name. In M2, ignore any formula