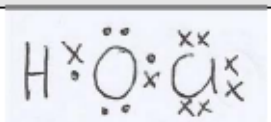
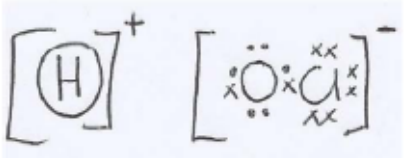
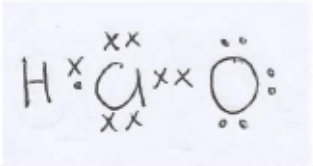
1) A (1)
2) C (1)
3) D (1)
4) D (1)
5) D (1)
6) D (1)
7) C (1)
8) C (1)
9) B (1)
10) A (1)
11) A (1)
12) D (1)
13) A (1)
14) C (1)
15)

	In (a) any units given must be correct. **Penalise incorrect units once only.** **Ignore SF except 1 SF in (i), (iii) and (iv). Penalise once only**		
(a)(i)	Volume Added/cm^3 | 25(.00) | 24.6(0) | 24.5(0) 24.55 (cm^3) Allow 24.6 (cm^3)	24.70 24.60	1
(a)(ii)	$NaOH + HCl \rightarrow NaCl + H_2O$ Ignore state symbols even if incorrect		1
(a)(iii)	Number of moles of NaOH $= (\frac{24.55}{1000} \times 2.5) = 6.1375 \times 10^{-2} = 0.061375$(mol) OR $6.14 \times 10^{-2} = 0.0614$ OR $6.1 \times 10^{-2} = 0.061$ Allow TE from 20(a)(i)	0.0613 0.06	1
(a)(iv)	6.1375×10^{-2} /0.061375/ 6.14×10^{-2} / 0.0614/0.061(mol) Allow TE = answer to (a)(iii)		1

(a)(v)	Multiply by 4 and by 36.5 **(1)** Using 6.1375×10^{-2} gives 8.96075 = 8.96 (g) OR Using 6.14×10^{-2} gives 8.9644 = 8.96(g) OR Using 6.1×10^{-2} gives 8.906 = 8.91(g) Answer to **3 SF** **(1)** Correct answer without working score (2) Allow TE from (a)(iv) ALLOW one mark for correct answer to 3SF where the multiplication by 4 has been omitted, e.g. $(6.1375 \times 10^{-2} \times 36.5 = 2.2401875 =)$ 2.24(g) **(1)**		2
(a)(vi)	The statement is valid as 8.96 ~9/very close Allow appropriate comment from answer to (a)(v) e.g 2.24 is not valid because it is too far away from 9g.	Just 'not valid / valid'	1
a(vii)	(Too) corrosive Damages eyes/burns (skin)/caustic Ignore Dangerous/Strong/Too concentrated	Just 'Harmful/Irritant/Toxic/Hazardous' Acid	1
(b)	 Allow all dots or all crosses ALLOW ionic dot and cross  Or dative covalent bond from chlorine 		1
(c)	$HCl + HOCl \rightarrow H_2O + Cl_2$ **(1)** Ignore state symbols even if incorrect Chlorine is toxic/poisonous **(1)** Allow fumes are toxic Ignore references to smell or colour	Just 'Harmful/ irritant/dangerous/ hazardous'	2

Number			
(d)(i)	$(2NaOH + Cl_2 \rightarrow NaCl + NaClO + H_2O)$ 0 -1 +1 All oxidation numbers correct **(1)** Type: Disproportionation **(1)** Allow phonetic spellings Allow redox **and** disproportionation Second mark consequential on the first except if (i) all the oxidation numbers are zero (ii) the plus sign is missing, (iii) the first two oxidation numbers are correct and the third one is positive If all the elemental oxidation numbers are given correctly then both marks are available	Just redox	2
(d)(ii)	Heat/increase temperature ALLOW (more) concentrated NaOH	Just 'warm' / 'excess NaOH' Acid	1
Number			
(d)(iii)	$3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$ OR $3Cl_2 + 6OH^- \rightarrow 5Cl^- + ClO_3^- + 3H_2O$ Formula of $NaClO_3$ / ClO_3^- **(1)** Rest of equation correct **(1)** Ignore state symbols even if incorrect		2

16)

(a)(i)	**C-F** bond is strong(er than C-Cl bond/C-OH bond) OR **C-F** bond is hard(er) to break (than C-Cl bond/C-OH bond) OR **C-F** bond enthalpy is high(er than C-Cl bond/C-OH bond) Ignore references to electronegativity	H-F bond is strong	1

(a)(ii)	The C-Cl dipole is the wrong way round **(1)** Allow reference to either only the carbon or only the chlorine having the wrong partial charge, e.g. "the carbon should be δ^+ not δ^-" The arrow goes from the carbon to the (oxygen of the) hydroxide ion but should be the other way around OR The pair of electrons goes from the carbon to the (oxygen of the) hydroxide ion but should be the other way around **(1)** Use of the term 'carbocation' means that only one of the first two marks may be awarded. The carbon bond to the hydroxy group should be to the oxygen and not to the hydrogen **(1)** Allow the above points to be drawn out correctly instead of stated in words Standalone marks IGNORE δ^- on fluorine atom Reference to lack of transition state Reference to absence of lone pair of electrons on the hydroxide ion	C+ Cl^- OH **group** Hydroxide	3
(a)(iii)	$CH_3CHClF + OH^- \rightarrow CH_2CHF + Cl^- + H_2O$ Organic product **(1)** Rest of equation correct **(1)** The organic molecules can be drawn displayed Allow any suitable metal hydroxide, e.g. $CH_3CHClF + NaOH \rightarrow CH_2CHF + NaCl + H_2O$ Allow C_2H_3F for the organic product Ignore state symbols even if incorrect.	CH_3CF	2
(b)	(i) Cl_2/chlorine (gas) **(1)** (ii) PCl_5/phosphorus (V) chloride **(1)** Allow Any other suitable reagents, such as HCl (and $ZnCl_2$) OR NaCl + concentrated H_2SO_4 OR $SOCl_2$ OR PCl_3 OR (concentrated) hydrochloric acid for (ii) (iii) HCl/hydrogen chloride **(1)** Ignore Reaction conditions	Cl_2(aq)/Cl• HCl(aq)	3

(c)(i)	$CH_3CH_2Cl + NH_3 \rightarrow CH_3CH_2NH_2 + HCl$ OR $CH_3CH_2Cl + NH_3 \rightarrow CH_3CH_2NH_3^{(+)}Cl^{(-)}$ OR $CH_3CH_2Cl + NH_3 \rightarrow CH_3CH_2NH_3^{(+)} + Cl^{(-)}$ OR $C_2H_5Cl + NH_3 \rightarrow C_2H_5NH_2 + HCl$ OR $CH_3CH_2Cl + 2NH_3 \rightarrow CH_3CH_2NH_2 + NH_4^{(+)}Cl^{(-)}$ OR $C_2H_5Cl + 2NH_3 \rightarrow C_2H_5NH_2 + NH_4^{(+)}Cl^{(-)}$	C_2H_7N	1
(c)(ii)	Nucleophilic **(1)** Substitution **(1)** ALLOW Just 'S_N2' for (1)	Elimination Addition S_N1	2
(c)(iii)	A **lone** pair (of electrons on the nitrogen atom)/ pair of non-bonding electrons	Pairs Just 'spare pair'	1
(c) (iv)	Ethanol / C_2H_5OH / CH_3CH_2OH	Alcohol	1
(d)(i)	Initiation $CCl_2F_2 \rightarrow CClF_2^{\bullet} + Cl^{\bullet}$ **(1)** --- Propagation 1 This must include a free radical from the initiation step reacting with ozone $Cl^{(\bullet)} + O_3 \rightarrow ClO^{(\bullet)} + O_2$ OR $CClF_2^{(\bullet)} + O_3 \rightarrow CClF_2O^{(\bullet)} + O_2$ **(1)** Propagation 2 $ClO^{(\bullet)} + O^{(\bullet)} \rightarrow Cl^{(\bullet)} + O_2$ OR $ClO^{(\bullet)} + O_3 \rightarrow Cl^{(\bullet)} + 2O_2$ **(1)** Allow propagation steps starting from $CClF_2^{\bullet}$/$CClF_2O^{(\bullet)}$ or either of the equations from propagation 1 --- Termination $Cl^{\bullet} + Cl^{\bullet} \rightarrow Cl_2$ OR $CClF_2^{\bullet} + Cl^{\bullet} \rightarrow CCl_2F_2$ OR $ClO^{\bullet} + ClO^{\bullet} \rightarrow Cl_2 + O_2$ **(1)** Allow other combinations of free radicals using those shown above. Ignore curly arrows	Any charges	4

(d)(ii)	The depleted ozone layer allows in (more) **UV** (radiation) **(1)** Which results in (skin) cancer/cataracts/mutation/ DNA damage/ Any reference to a chain reaction/ One $Cl^{(\bullet)}$ destroys many ozone molecules/ $Cl^{(\bullet)}$ is regenerated/ $Cl^{(\bullet)}$ catalyst/ death of marine organisms such as phytoplankton **(1)** Standalone marks Any reference to greenhouse effect or global warming or infrared radiation scores (0)	Cancer from $Cl^{(\bullet)}$	2

17)

(a)	$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ 4s^2$ OR $(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^8$ ALLOW capital S P D Allow subscripts (e.g. $(1s^2)\ 2s_2\ 2p_6\ 3s_2\ 3p_6\ 4s_2\ 3d_8$)		**1**
(b)	(A_r for Ni) = (58 x 0.6902) + (60 x 0.2732) + (62 x 0.0366) or a correct fraction using percentages **(1)** (= 58.6928) [calculator value] = 58.69 (**must be to 2 dp**) **(1)** 2nd mark CQ on numbers transcribed Correct answer with no working **(2)** IGNORE Units of any kind (e.g. 'g', 'g mol^{-1}', 'amu', etc.)	58.68 (as rounding error)	**2**

(c)(i)	Moles of nickel = $\frac{5.87}{58.7}$ = 0.1(00) (mol) **(1)** Moles CO = 0.1(00) x 4 = 0.4(00) (mol) Answer CQ on 4 x mol Ni **(1)** Volume of CO = 0.4(00) x 24 (dm^3) = 9.6 (dm^3) ALLOW 9600 **cm^3** Answer CQ on 24 x mol CO **(1)** Correct answer with no working scores **(3)**	9.6 dm^3 **mol^{-1}** (no 3rd mark) 9.6 dm^{-3} (no 3rd mark) OR Any other incorrect units (no 3rd mark)	**3**
(c)(ii)	(Number of CO molecules = 0.400 x 6.02 x 10^{23}) = 2.408 x 10^{23} Answer CQ on moles / volume of CO in (c)(i) IGNORE sf except 1 sf IGNORE Any units, even if incorrect		**1**
(d)(i)	Moles of NiO = $\frac{1.494}{74.7}$ = 0.02(00) (mol) **(1)** Moles HNO_3 = 0.02(00) x 2 = 0.04(00) (mol) Answer CQ on 2 x mol NiO **(1)** Volume of HNO_3 = $\frac{0.04(00) \times 1000}{2.00}$ = 20(.0) (cm^3) ALLOW 0.02(00) **dm^3** Answer CQ on mol HNO_3 **(1)** Correct answer with no working scores **(3)** Penalise wrong units ONCE only		**3**
(d)(ii)	To ensure all the **acid** reacts / all the **acid** is used up / all the **acid** is neutralized IGNORE References to 'yield' / reaction going to completion / just 'acid is the limiting reagent'	To ensure all the **reactants** are used up	**1**

(d)(iii)	Fizzing / effervescence / frothing / bubbles / gas released IGNORE spilling (over) / spillage References to 'vigorous', 'exothermic', 'violent' / **just** 'safety'	(Mixture) **boils** Quantity of reagents / 'displacement' of solution on adding solid	**1**
(d)(iv)	$NiCO_3(s) + 2HNO_3(aq) \rightarrow Ni(NO_3)_2(aq) + H_2O(l) + CO_2(g)$ ALLOW correct ionic equation $NiCO_3(s) + 2H^+(aq) \rightarrow Ni^{2+}(aq) + H_2O(l) + CO_2(g)$ All species correct **(1)** Balancing and all state symbols correct **(1)** 2nd mark is dependent on 1st mark (ie all species correct)	$H_2CO_3(aq)$ scores **(0)** overall	**2**
* **(d)(v)**	**First mark:** **Filter** (off the excess nickel(II) carbonate / solid) **(1)** **Second mark:** **Boil / heat** (to drive off some of the water) **(1)** **IGNORE** just 'evaporation' (as the technique of boiling / heating is required here) **Third mark:** Leave to cool / leave to crystallize / evaporate (water) slowly / leave (for water) to evaporate **(1)** **Fourth mark:** **Dry** (the crystals) **(1)** IGNORE Any washing of the crystals immediately prior to drying them NOTE If heat **to dryness** in the second stage, award (1) mark if filtration is **first** stage If filtration is not the first stage, award (1) mark for **steps 2, 3 and 4 all correct**	**Just** "warm" the filtrate / solution OR 'heat the filtrate **to dryness**' (Adding to a) drying agent Use of Bunsen burner or direct heating to dry crystals	**4**

18)

(a)	(Protons) **18** (Electrons) **18** (Neutrons) **22** All three numbers correct for the mark		**1**
(b)	(Position in the Periodic Table) depends upon atomic number / proton number OR Ar (atom) has (one) fewer proton(s) (than K atom) OR K (atom) has (one) more proton(s) (than Ar atom) OR K has atomic number 19 (whereas) Ar has atomic number 18 OR Ar has 18 protons, K has 19 protons IGNORE 'Elements are not arranged in order of (relative) atomic mass' IGNORE Mention of numbers of electrons / numbers of shells (of electrons) IGNORE Arranged in vertical groups in accordance to properties / Argon is a noble gas		**1**

(c)	**First mark** Property / trend / pattern ALLOW Any named property (e.g. atomic radius, ionization energy, melting temperature) **(1)** **Second mark** **Repeated** (across each period) OR **Regular** (across each period) OR **Re-occurring** (across each period) **(1)** NOTE Statement such as: "A repeating trend across a period / across each period" scores **(2)**		**2**
(d)(i)	Phosphorus / P / P_4 OR Sulfur / S / S_8 OR Chlorine / Cl / Cl_2 IGNORE Argon / Ar		**1**
(d)(ii)	(The covalent) **bonds** are **strong** (throughout the lattice) **(1)** (therefore) a lot of **energy** is required to break the bonds / a lot of **energy** is needed to overcome the attractions (between atoms) / 'more **energy**' is required to break the bonds /'more **energy**' is needed to overcome the attractions (between atoms) / 'greater amount of **energy**' is required to break the bonds /'greater amount of **energy**' is needed to overcome the attractions (between atoms) **(1)**	**MENTION OF ANY OF THE FOLLOWING SCORES (0) OVERALL** '(simple) molecular silicon' **(0)** 'molecules of silicon' **(0)** 'silicon has ions' / 'silicon is ionic' **(0)** 'intermolecular forces' / 'van der Waals' forces' / 'London forces' / 'forces between the molecules' **(0)** 'metallic bonding' **(0)**	**2**

Number				
(d)(iii)	**ALLOW reverse arguments in each case** **Any two from four:-** ●magnesium ions / magnesium atoms are small**er** (than sodium ions / sodium atoms) **(1)** **NOTE:** Allow symbols (e.g. Mg or Mg^{2+}) ●magnesium **ions** are Mg^{2+} whereas sodium **ions** are Na^{+} OR Mg^{2+} / magnesium **ions** have a larg**er** charge (density) (than Na^{+} /sodium **ions**) **(1)** **[NOTE:** It follows that the statement that "Mg^{2+} ions are smaller than Na^{+} ions" would score the first two scoring points above**]** ●magnesium has more **delocalised** electrons (than sodium) **(1)** IGNORE 'free electrons' IGNORE just 'sea of electrons' ●magnesium is close-packed (but sodium is not close-packed) **(1)**			3
	Third mark (stand-alone): · more / a lot of (heat) energy is needed to break (metallic) bonds in Mg (than in Na) OR · attraction between the positive ions and (delocalised) electrons is strong**er** in magnesium (than in sodium) **(1)**	attraction between **nucleus** and (delocalised) electrons (no third mark) mention of **intermolecular forces / molecules** (no third mark)		
	IGNORE Just 'metallic bonding in Mg stronger than that in Na'	ionic bonding (no third mark) attraction between Mg^{2+} ions (no third mark) **NOTE:** arguments based on ionization energies scores **(0) overall** **OR** any suggestion of removal of outer shell electrons as part of the melting process scores **(0) overall**		