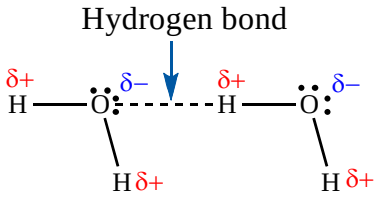
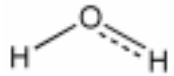
Question			Expected Answers	Marks	Additional Guidance
1	(a)	(i)	the energy required to remove one electron ✓ from each atom in one mole ✓ of gaseous atoms ✓	3	**ALLOW** 3 marks for: the energy required to remove one mole of electrons ✓ from one mole of atoms ✓ atoms in the gaseous state ✓ If no definition, **ALLOW one** mark for the equation below, including state symbols. $X(g) \rightarrow X^+(g) + e^-$ / $X(g) - e^- \rightarrow X^+(g)$ **ALLOW** e for electron **IGNORE** state symbol for electron
	(b)	(i)	outer electrons closer to nucleus **OR** radii decreases ✓ nuclear charge increases **OR** protons increase ✓ electrons added to the same shell **OR** screening **OR** shielding remains the same ✓	3	 **IGNORE** 'atomic number increases' **IGNORE** 'nucleus gets bigger' 'charge increases' is not sufficient **ALLOW** 'effective nuclear charge increases' **OR** 'shielded nuclear charge increases' **ALLOW** shielding is similar
		(ii)	atomic radii increase **OR** there are more shells ✓ there is **more** shielding **OR more** screening ✓	3	**ALLOW** electrons in higher energy level **ALLOW** electrons are further from the nucleus **DO NOT ALLOW** more orbitals **OR** more sub-shells **DO NOT ALLOW** different shell or new shell There must be a clear comparison: *e.g. '***more** shielding'**,** **'increased** shielding'. *i.e.* **DO NOT ALLOW** just 'shielding'. **ALLOW** '**more** electron repulsion from inner shells'

Question			Expected Answers	Marks	Additional Guidance
			the nuclear attraction decreases **OR** Increased shielding / distance outweigh the increased nuclear charge ✓		**Nuclear OR proton(s) OR nucleus spelt correctly ONCE** **ALLOW** 'nuclear pull' **IGNORE** any reference to 'effective nuclear charge'
	(c)	**(i)**	$O^+(g) \longrightarrow O^{2+}(g) + e^-$ ✓	**1**	answer **must have** state symbols **ALLOW** e for electron **ALLOW** $O^+(g) - e^- \rightarrow O^{2+}(g)$ **DO NOT ALLOW** $O^+(g) + e^- \longrightarrow O^{2+}(g) + 2e^-$ **IGNORE** state symbol for electron
		(ii)	the O^+ ion, is smaller than the O atom **OR** the electron repulsion/shielding is smaller **OR** the proton : electron ratio in the 2+ ion is greater than in the 1+ ion ✓	**1**	**ALLOW** the outer electrons in an O^+ ion are closer to the nucleus than an O atom **DO NOT ALLOW** 'removed from next shell down'
			Total	**11**	

Question			Expected Answers	Marks	Additional Guidance
2	(a)	(i)	number of protons (in the nucleus) ✓	1	**ALLOW** proton number **ALLOW** number of protons in an atom **IGNORE** reference to electrons
		(ii)	$(1s^2)2s^22p^63s^23p^63d^24s^2$ ✓	1	**ALLOW** $1s^2$ written twice **ALLOW** subscripts **ALLOW** $4s^2$ before $3d^{2+}$
		(iii)	Mn / manganese **and** d ✓	1	**ALLOW** D
	(b)	(i)	 Shape of water with at least one H with δ+ and at least one O with δ– ✓ H-bond between H in one water molecule and a lone pair of an O in another water molecule✓ hydrogen bond labelled **OR** H_2O has hydrogen bonding ✓	3	all marks can be awarded from a labelled diagram If HO_2 shown then **DO NOT ALLOW** 1st mark Dipole could be described in words so it does **not** need to be part of diagram. At least one hydrogen bond **must** clearly hit a lone pair Lone pair interaction could be described in words so it does **not** need to be part of diagram. **DO NOT ALLOW** hydrogen bonding if described in context of intramolecular bonding, *ie* 
		(ii)	no hydrogen bonding **OR** weaker intermolecular forces ✓	1	**DO NOT ALLOW** 'weaker'/ 'weak' hydrogen bonding **ALLOW** weaker van der Waals' forces **ALLOW** weaker dipole-dipole interactions **DO NOT ALLOW** 'weak intermolecular forces' (ie comparison essential here) **DO NOT ALLOW** 'no intermolecular forces'

Question			Expected Answers	Marks	Additional Guidance
	(c)		van der Waals' forces **OR** induced dipole interactions ✓ number of electrons increases ✓ **Down the group**, intermolecular forces / van der Waals' forces increase **OR** **Down the group**, more energy needed to break intermolecular / van der Waals' forces ✓	**3**	**electron(s) must be seen and spelt correctly ONCE** **ALLOW** number of electron shells increases **ALLOW** iodine has most electrons **ALLOW** chlorine has the least electrons For **'Down the group'** **ALLOW** 'Increase in boiling points' or 'Molecules get bigger'
	(d)	**(i)**	goes brown ✓	**1**	**ALLOW** yellow **OR** orange **OR** any shade of yellow, orange and brown, *e.g.* reddish-brown **IGNORE** precipitate
		(ii)	iodine and (potassium) chloride ✓ $Cl_2 + 2I^- \longrightarrow I_2 + 2Cl^-$ ✓	**2**	**DO NOT ALLOW** formulae (*i.e.* names essential) **ALLOW** any correct multiple including fractions **IGNORE** state symbols
		(iii)	chlorine / Cl_2 is more reactive (than iodine) **OR** chlorine / Cl_2 is a more powerful oxidising agent ✓	**1**	**ALLOW** chlorine is better at electron capture **OR** chlorine attracts electrons more **ALLOW** iodine is less reactive (than chlorine) **ALLOW** iodide (ion) / I^- is a stronger reducing agent **DO NOT ALLOW** Cl is more reactive **DO NOT ALLOW** explanation in terms of displacement **DO NOT ALLOW** chlorine is more electronegative
		(iv)	goes purple / violet / lilac / pink ✓	**1**	**ALLOW** pink **OR** any combination of purple, violet, lilac and pink
			Total	**15**	

Question			er	Marks	Guidance
3	(a)	(i)	A region (within an atom) that can hold (up to) two electrons ✓ (with opposite spin)	1	**ALLOW** 'can be found' **OR** 'contains' **OR** 'has' etc. for 'can hold' **ALLOW** 'area' **OR** 'volume' **OR** 'space' **OR** 'somewhere' etc. for region **DO NOT ALLOW** path of an electron **IGNORE** references to 'orbitals being parts of sub-shells'
		(ii)	$1s^2 2s^2 2p^6 3s^2 3p^4$ ✓	1	**ALLOW** subscripts, capitals **IGNORE** $1s^2$ seen twice
		(iii)	7 ✓	1	
	(b)		(The amount of substance which contains) as many particles as there are carbon **atoms** in 12g of ^{12}C (atoms) ✓	1	**ALLOW** 6.02×10^{23} particles (atoms, molecules, ions etc.) **OR** N_A particles **OR** L particles **ALLOW** 'Avogadro number' in place of N_A particles **ALLOW** 'Number of atoms in 12 g of ^{12}C' **DO NOT ALLOW** 'the number of particles in 12g of ^{12}C atoms'
	(c)		Energy (needed) to remove an electron ✓ from **each atom** in **one mole** ✓ of **gaseous atoms** ✓	3	**ALLOW** 'Energy to remove one mole of electrons from one mole of gaseous atoms' for three marks **IGNORE** 'element' **ALLOW** 'Energy needed to remove an electron from one mole of gaseous atoms (to form one mole of gaseous 1+ ions') for two marks For third mark: **ALLOW** ECF if wrong 'particle' is used in second marking point but is described as being gaseous eg 'molecule' instead of 'atom' If no definition, **ALLOW** one mark for $X(g) \rightarrow X^+(g) + e^-$ **OR** $X(g) - e^- \rightarrow X^+(g)$ **ALLOW** e^- for electron **IGNORE** state symbols on e

Question			er	Marks	Guidance
	(d)	(	***From F to Ne*** *Nuclear charge mark:* Ne has (one) more proton **OR** Nuclear charge increases ✓ *Same shell or energy level mark:* (Outermost) electrons are in the same shell **OR** energy level **OR** (Outermost) electrons experience the same shielding ✓ *Nuclear attraction mark:* Greater nuclear attraction (on outermost electrons) **OR** Outer electrons are attracted more strongly (to the nucleus) ✓	3	**Use annotations with ticks, crosses, ECF etc for this part** **ALLOW** proton number increases but **IGNORE** atomic number increases **IGNORE** nucleus gets bigger **IGNORE** 'charge increases' ie must be nuclear charge **IGNORE** 'effective nuclear charge increases' **ALLOW** sub-shell for shell but **IGNORE** orbitals **ALLOW** shielding is similar **ALLOW** screening for shielding **IGNORE** Atomic radius decreases *(because given in question)* **OR** outermost electrons are closer **DO NOT ALLOW** 'distance is the same' for second mark **ALLOW** greater nuclear pull for greater nuclear attraction **DO NOT ALLOW** 'greater nuclear charge' instead of 'greater nuclear attraction' for the third mark **IGNORE** 'pulled closer' for 'pulled more strongly'
		(ii)	***From Ne to Na*** *Extra shell or energy level mark:* Na has (one) more shell(s) **OR** energy level ✓ *Shielding mark:* (Outermost) electron experiences greater shielding ✓ *Nuclear attraction mark:* Less nuclear attraction (on outermost electrons) **OR** Outer electrons are attracted less strongly (to nucleus) ✓	3	**Use annotations with ticks, crosses, ECF etc for this part** **ALLOW** 'next' shell **OR** 'new' shell **ALLOW** (outermost) electrons in a higher energy level **ALLOW** outermost electrons **OR** shell further from nucleus **IGNORE** Atomic radius increases *(because given in question)* **DO NOT ALLOW** orbitals **OR** sub-shells **ALLOW** screening for shielding **ALLOW** more electron repulsion from inner shells **ALLOW** 'less nuclear pull' for 'less nuclear attraction' **DO NOT ALLOW** 'less nuclear charge' for 'less nuclear attraction' for third mark. There must be a clear comparison
			Total	**13**	

Question			Answer	Mark	Guidance
4	(a)	(i)	***Creating the dipole mark*** uneven distribution of electrons ✓ ***Type of dipole mark*** creates an instantaneous dipole **OR** temporary dipole ✓ ***Induction of a second dipole mark*** causes induced dipole(s) in neighbouring molecules ✓	3	**Use annotations with ticks, crosses ECF etc. for this part** **ALLOW** movement of electrons **ALLOW** changing electron density **ALLOW** 'transient', 'oscillating', 'momentary', 'changing' **ALLOW** 'induces a dipole in neighbouring molecules' **ALLOW** 'causes a resultant dipole in neighbouring molecules' **ALLOW** 'atoms' for 'molecules'
		(ii)	boiling points increase down the group ✓ greater number of electrons **OR** stronger intermolecular forces **OR** stronger van der Waals' forces ✓ more energy needed to break intermolecular **OR** van der Waals' forces ✓	3	**Use annotations with ticks, crosses ECF etc. for this part** **ALLOW** Bpt of iodine is high**est OR** Bpt of chlorine is low**est** **ALLOW** Cl for chlorine etc. For 'down the group' **ALLOW** 'as molecules get bigger' **ALLOW** number of **electron** shells increases **IGNORE** 'more shells' (if no reference to electrons) **ALLOW** 'more' for 'stronger' **ALLOW** iodine has most electrons **ALLOW** chlorine has fewest electrons **DO NOT ALLOW** any implication that the attraction is between atoms not molecules for third mark
	(b)		Same number of **outer(most)** electrons **OR** same **outer(most)** electron structure ✓	1	**ALLOW** same number of electrons in outer shell **ALLOW** It has seven outer electrons **IGNORE** same group **DO NOT ALLOW** 'same number of electrons'

Question			er	Mark	Guidance
	(c)	(i)		6	**Use annotations with ticks, crosses ECF etc. for this part**
			Colours: (Add Br_2 to NaCl,) (Cyclohexane layer) turns orange **OR** yellow ✓		**ALLOW** any combination of these but no others
			(Add Br_2 to NaI,) (Cyclohexane layer) turns purple **OR** lilac **OR** violet **OR** pink **OR** mauve ✓		**ALLOW** any combination of these but no others **DO NOT ALLOW** 'precipitate' with either colour
			Equation: $Br_2 + 2I^- \rightarrow I_2 + 2Br^-$ ✓		**DO NOT ALLOW** equation mark if incorrect equation(s) also seen **IGNORE** $Br_2 + 2Cl^- \rightarrow Br_2 + 2Cl^-$ **IGNORE correct** non-ionic version of equation **IGNORE** state symbols
			Reactivity: Reactivity decreases down the group **OR** Oxidising power decreases down the group ✓		**ALLOW** Chlorine is the most reactive **ALLOW** Cl for chlorine etc. **ALLOW** Iodine is the least reactive
			Explanations: Chlorine will gain electron easiest **OR** form negative ion easiest ✓		**ALLOW** chlorine is best at electron capture **ALLOW** chlorine has 'greatest' electron affinity **IGNORE** chlorine is most electronegative **DO NOT ALLOW** explanations in terms of displacement ***Quality of Written Communication –*** *Electron(s)* ***OR*** *negative spelled correctly at least* ***ONCE*** *for marking point 5*
			Because chlorine (atom) is smallest **OR** Outer(most) shell of chlorine least shielded **OR** Nuclear attraction on electrons of chlorine is greatest ✓		**ALLOW** Chlorine atom has fewest shells **ALLOW** outer(most) shell closest to the nucleus **ALLOW** Chlorine atom has lowest shielding **ORA** for marking points 4, 5 and 6

Question			er	Mark	Guidance
	(c)	(ii)	Bromine is toxic ✓	1	**ALLOW** cyclohexane is toxic **ALLOW** bromine irritates the lungs **DO NOT ALLOW** Cl_2 is toxic **IGNORE** 'strong smelling' **IGNORE** 'halogens' are toxic
	(d)	(i)	$2F_2 + 2H_2O \rightarrow 4HF + O_2$ ✓	1	**ALLOW** correct multiples, including use of ½ O_2 **ALLOW** 4FH **IGNORE** state symbols
		(ii)	Oxygen has been oxidised as (oxidation number has increased from) O = –2 to O = 0 ✓ Fluorine has been reduced as (oxidation number has decreased from) F = 0 to F = –1 ✓	2	**IGNORE** references to oxygen in any incorrect products **DO NOT ALLOW** $O_2 = -2 \rightarrow O = 0$ but **ALLOW** $F_2 = 0 \rightarrow F = -1$ **ALLOW** 'F is reduced from 0 to –1' regardless of product (or no product) in **5d(i)** except **ALLOW ECF** for F = –2 **if** H_2F is seen **ALLOW** one mark for O = –2 and $O_2 = 0$ **AND** $F_2 = 0$ and F = –1 if **no reference OR incorrect reference** to oxidation / reduction is seen Look at equation in **5d(i)** for oxidation numbers **if not seen in 5d(ii)** **IGNORE** reference to electron loss / gain if correct **DO NOT ALLOW** incorrect reference to electron loss / gain
	(e)	(i)	$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^1$ ✓	1	**IGNORE** $1s^2$ twice **ALLOW** $4s^2$ before $3d^{10}$ **ALLOW** '3D'
		(ii)	GaF_3 ✓	1	
			Total	**19**	