1. (a) (Atoms of) the same element / with same protons.... with different masses/different numbers of neutrons ✓ [1]

(b)

isotope	percentage composition	number of	
		protons	neutrons
^{191}Ir	38%	77	114
^{193}Ir	62%	77	116
	✓	✓	✓

*Accept 37-39% for ^{191}Ir; 61-63% for ^{193}Ir but **must** add up to 100.*

[3]

(c)(i) average atomic mass/weighted mean/average mass ✓

compared with carbon-12 ✓

1/12th of mass of carbon-12/on a scale where carbon-12 is 12 ✓

mass of 1 mole of element/mass of 1 mole of carbon-12 is equivalent to first two marks

"mass of the element that contains the same number of atoms as are in 1 mole of carbon-12" ⟶ 2 marks (mark lost because of mass units)

[3]

(ii) 38 x 191/100 + 62 x 193/100 ✓ = 192.2 ✓

Answers from other percentages above:

37 x 191/100 + 63 x 193/100 ✓ *= 192.3* ✓

39 x 191/100 + 61 x 193/100 ✓ *= 192.2* ✓

[2]

(d)(i) Simplest (whole number) ratio of atoms/moles/elements ✓ [1]

(ii) ratio Ir : F = 62.75/192 : 37.25/19 or 0.327 : 1.96 ✓

= 1 : 6 or formula = IrF_6 ✓

(or using answer for Ir from (c)(ii)) [2]

(iii) $Ir + 3F_2 \longrightarrow IrF_6$ ✓ (consequential on response to (ii)) [1]

[Total: 13]

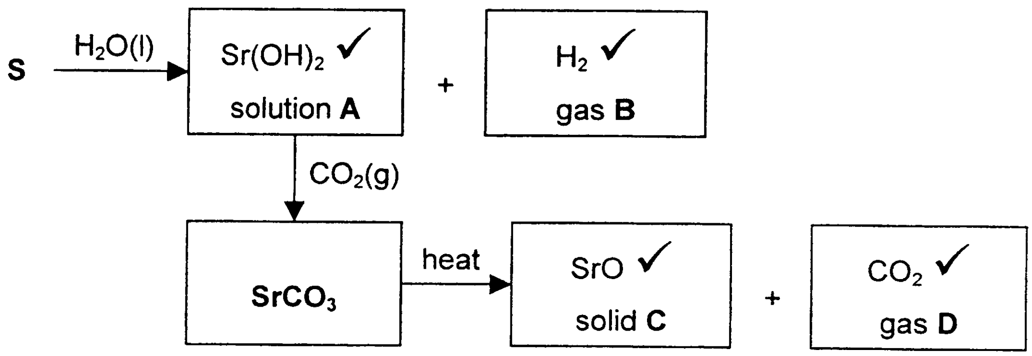
2. (a) *trend in reactivity*: more reactive down group ✓

explanation: electrons lost more easily / ionisation energies decrease / less attraction or pull ✓

some attempt to relate this increase in size of atom / more shells / energy levels ✓

and **increase** in shielding ✓ [4]

(b)



[4]

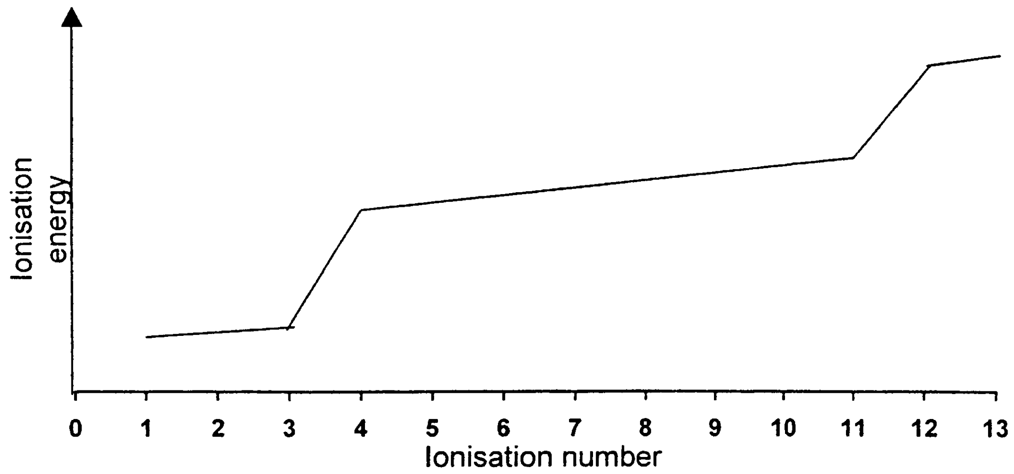
[Total: 8]

3. (a)(i) $O^+(g) \longrightarrow O^{2+}(g) + e^-$ equation ✓;
state symbols **but** an electron must be in the equation somewhere ✓ [2]

(ii) Large difference between 6th and 7th ionisation energies ✓
marks a different shell (closer to nucleus) ✓ [2]

(b)(i) $1s^2 2s^2 2p^6 3s^2 3p^1$ ✓ [1]

(ii)



sharp rise between ionisation 3 and ionisation 4 ✓

sharp rise between ionisation 11 and ionisation 12 ✓

i.e. the two steepest rises

(for 2,8,3 pattern the wrong way around, award 1 mark)

[2]

(c)(i) $4Al(s) + 3O_2(g) \longrightarrow 2Al_2O_3(s)$ equation ✓; state symbols ✓ [2]

(ii) Al^{3+} ions / highly charged aluminium ions ✓ are small ✓;
O^{2-} ions / anions / negative ions are large ✓;
O^{2-} ions / anions / negative ions are polarised / distorted ✓

4 ⟶ [3 max]

(d) $M(Al_2O_3) = 102$ g mol^{-1} ✓

amount of Al_2O_3 = 25/102 = 0.2451 / 0.245 / 0.25 ✓ [2]

[Total: 14]

4. (a) HOCl: +1 ✓ HCl: –1 ✓ [2]

(b) covalent bonds shown correctly ✓

all molecule correct (i.e. chlorine's and oxygen's lone pairs) ✓ [2]

(c)(i) electron **pairs** repel ✓

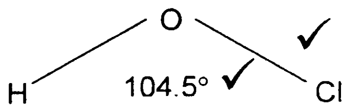
as far apart as possible ✓

the number of electron pairs (surrounding central atom) decides the shape ✓

lone pairs repel more (than bonded pairs) ✓

4 ⟶ [3 max]

(ii)



✓ allow 104 – 105°

[2]

(d)(i) loss of electrons / ox number increases / gains oxygen / loses hydrogen ✓ [1]

(ii) brown / orange / yellow colour ✓ [1]

(iii) $Cl_2 + 2I^- \longrightarrow 2Cl^- + I_2$ ✓ [1]

(e)(i) *Molar mass* of NaCl = 58.5 g mol^{-1} ✓

mass of NaCl dissolved = 58.5 x 4 g = 234 g ✓ [2]

(ii) 2 mol NaCl ⟶ 1 mol Cl_2

∴ amount of Cl_2 produced = 2 mol ✓ *(i.e. half 1st answer to (e)(i))*

volume of Cl_2 produced = 24 x 2 = 48 dm^3 ✓ [2]

(iii) 1 dm^3 brine ⟶ 48 dm^3 $Cl_2(g)$

$2.5 \times 10^9/48$ dm^3 brine ⟶ 2.5×10^9 dm^3 $Cl_2(g)$

∴ 5.2×10^7 (dm^3) ✓ (but wrong unit is wrong!) [1]

[Total: 17]

5. (a) diagram of H bonding between water molecules (O of 1 molecule to H of another) ✓

dipoles shown ✓ with lone pair involved in bond ✓

(could be in words; could describe another molecule such as NH_3.) [3]

Two properties from:

property	higher melting/boiling point than expected ✓
explanation	strength of H bonds/H-bonds need to be broken ✓ ***must imply that intermolecular bonds are broken***
property	ice is lighter than water/ max density at 4°C ✓
explanation	H bonds hold H_2O molecules apart / open lattice in ice / H-bonds are longer ✓
property	high surface tension/viscosity ✓
explanation	strength of H bonds/H-bonds need to be broken ✓

4 max ⟶ [4]

Q – legible text with accurate spelling, punctuation and grammar ✓

[1]

[Total: 8]