Question			Expected Answers	Marks
1	(a)	(i)	^{79}Br has two ✓ less neutrons than ^{81}Br ✓	[2]
		(ii)	^{79}Br and ^{81}Br have same number of protons ✓ and same number of electrons ✓	[2]
	(b)	(i)	$1s^2 2s^2 2p^6 3s^2 3p^6 ....3d^{10} 4s^2 4p^5$ ✓ ✓ Award 1 mark for p^5.	[2]
		(ii)	Highest energy sub-shell/sub-shell/ being filled is the p sub-shell/outer electrons are in a p (sub-shell/orbital/shell) ✓	[1]
	(c)	(i)	Number **AND** type of atoms (making up a molecule)/number of atoms of each element ✓ ***Not*** *ratio*	[1]
		(ii)	$P_4 + 6\ Br_2 \longrightarrow 4\ PBr_3$ ✓	[1]
		(iii)	ratio P : Br = 16.2/31 : 83.8/79.9 /= 0.52 : 1.05 /= 1 : 2 ✓ Empirical formula = PBr_2 ✓ Correct compound = P_2Br_4 /phosphorus(II) bromide but **not** PBr_2 ✓	[3]
				Total: 12

Question			Expected Answers	Marks
2	(a)		shared pair ✓ of electrons ✓ *i.e. 'shared electrons' is worth 1 mark. pair of electrons for second marks*	[2]
	(b)		H_2O: all correct including lone pairs around O ✓ CO_2: correct covalent bonds around carbon ✓ lone pairs added around oxygen atoms ✓ (must be 'dot AND cross' or electron source clearly shown (different coloured for source is OK)	[3]
	(c)	(i)	molecule shown as non-linear ✓ angle: 104 - 105° ✓ molecule shown as linear ✓	[4]
		(ii)	angle: 180° ✓ shape of H_2O shape of CO_2 Electron pairs repel / groups (or regions) of electrons repel/ electron pairs get as far apart as possible ✓ Oxygen in water surrounded by 4 areas of electron density/2 bonds and 2 lone pairs **AND** Carbon in CO_2 surrounded by 2 regions of electron density/2 double bonds ✓	[2]
	(d)	(i)	Attraction of electrons ✓ in a bond ✓ towards an atom	[2]
		(ii)	CO_2 is symmetrical/H_2O is not symmetrical ✓ In CO_2, dipoles cancel/in H_2O, the dipoles don't cancel ✓	[2]
				Total: 1

Question	Expected Answers	Marks
3 (a)	Energy change when each atom in 1 mole ✓ of gaseous atoms ✓ loses an electron ✓ (to form 1 mole of gaseous 1+ ions).	[3]
(b)	increasing nuclear charge/number of protons ✓ electrons experience greater attraction or *pull* / atomic radius decreases / electrons added to same shell /same or similar shielding ✓	[2]
(c)	N has an single electron in each p orbital/ O has a paired p orbital ✓ in O, this pairing leads to repulsion/higher energy level ✓	[2]
(d)	(From 2 ⟶10 ⟶18 / down group) 1st ionisation energies decrease/easier to remove electrons ✓ electron is further from nucleus/ atomic radius increases/ electron in a different shell/ atoms increase in size ✓ (***not** sub-shell or orbital*) electron experiences **more** shielding ✓ (***more** is essential here*) distance and shielding outweigh the increased nuclear charge ✓ ***NOT: attraction/pull; effective nuclear charge***	[4]
		Total: 11

Question			Expected Answers	Marks
4	(a)		Strontium reacts with oxygen/strontium oxide forms/SrO forms ✓ $2Sr + O_2 \longrightarrow 2SrO$ / $Sr + {}^1/_2 O_2 \longrightarrow SrO$ ✓	[2]
	(b)	(i)	In Sr, oxidation number = 0 ✓ In $Sr(OH)_2$, oxidation number = (+)2 ✓ *OR* Oxidation number increases from $Sr \longrightarrow Sr(OH)_2$ ✓ by 2 ✓	[2]
		(ii)	$0.438/87.6 = 5.00 \times 10^{-3}$ / 0.00500 mol ✓	[1]
		(iii)	$0.00500 \times 24.0 = 0.120\ dm^3$ ✓ (accept 120 cm^3)	[1]
		(iv)	$0.00500 \times 1000/200 = 0.0250\ mol\ dm^{-3}$ ✓	[1]
	(c)	(i)	heat ✓	[1]
		(ii)	...3..$SrO(s)$ + ...2..$Al(s)$ $\longrightarrow$ ...3..$Sr(s)$ + ...$Al_2O_3(s)$ ✓	[1]
		(iii)	Molar mass of $SrCO_3$ = 87.6 + 12 + 16x3 = 147.6 g mol^{-1} ✓ Mass $SrCO_3$ required = 100 x 147.6/87.6 = 168 tonnes ✓ Mass of ore needed = mass $SrCO_3$ x 100/2 = 168 x 100/2 = 8400 tonnes / 8425 tonnes *(from 168.484931507)* ✓ *(answer depends on rounding)* *5000 tonnes is 50 x 100 tonnes: worth 1 mark*	[3]
		(iv)	98% waste produced which must be disposing of /made into something worthwhile / CO_2 being removed by something sensible/ any sensible comment ✓	[1]
				Total: 1

Question	Expected Answers	Marks
5	***Physical states of halogens*** chlorine gas; bromine liquid; iodine solid/ boiling point increases from $Cl_2 \longrightarrow Br_2 \longrightarrow I_2$ ✓ number of electrons/number of shells increases down group ✓ van der Waals' forces/ induced dipole-dipole interactions/ AW ✓ stronger forces to be broken (between the molecules) ✓	[4]
	Displacement with chloride, nothing happens ✓ with iodide, $\longrightarrow$ darker orange/brown/darker yellow /$\longrightarrow$ purple with organic solvent ✓ $Br_2 + 2I^- \longrightarrow I_2 + 2Br^-$ ✓ (or a full equation, e.g. with NaI) The strength of oxidising power is $Cl_2 > Br_2 > I_2$ / Reactivity order is $Cl_2 > Br_2 > I_2$ ✓	[4]
	Quality of written communication • organise relevant information clearly and coherently, using specialist vocabulary when appropriate; **Evidence should link together two of the marking points:** e.g. size of the intermolecular forces linked to temperature at which a substance changes state / number of electrons linked to magnitude of intermolecular forces /amount of energy needed to overcome forces order of reactivity linked to observation ✓ The key is a 'because' or 'therefore': i.e bromine doesn't displace chlorine because it is less reactive. Greater intermolecular forces: therefore more energy needed to break them.	[1]
		Total: 9