C2.1 Development of the periodic table

<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
<th>Marks</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pattern broke down because of undiscovered elements, so not all octaves had similar properties.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2 a</td>
<td>tellurium (Te), iodine</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2 b</td>
<td>at certain places pattern of similar elements recurring at regular intervals was broken until order of atomic weights reversed, no good reason for reversing order so other scientists doubted validity of periodic table, discovery of internal structure of atoms → chemists found atomic number was important in ordering elements, not atomic mass, using number of protons in atoms to order elements worked perfectly, anomalies explained by existence of isotopes with different numbers of neutrons</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>gaps for undiscovered elements and predicted their properties, when elements were discovered predictions were remarkably accurate</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
C2.2 Electronic structures and the periodic table

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>1 a</td>
<td>repeated at regular intervals</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1 b i</td>
<td>vertical column</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1 b ii</td>
<td>horizontal row</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2 a</td>
<td>many more metals. 75%–80%</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2 b</td>
<td>lose one or more electrons (to form stable electronic structure)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3 a</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3 b</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3 c</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3 d</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3 e</td>
<td>8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3 f</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3 g</td>
<td>8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3 h</td>
<td>7</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>same number of electrons in highest energy level / outermost shell</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>very stable electron arrangements</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
# C2.3 Group 1 – the alkali metals

<table>
<thead>
<tr>
<th>Question number</th>
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</tr>
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<tbody>
<tr>
<td>1</td>
<td>to avoid reactions with air / O₂ and H₂O</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>melting point decreases</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>all have one electron in outermost shell,</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>lose this to form ions</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>producing ions with stable electronic structure</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4 a</td>
<td>2Cs (s) + I₂ (g) → 2CsI (s) white solid</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4 b</td>
<td>2Cs (s) + Br₂ (g) → 2CsBr (s) white solid</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>explodes on contact as H₂ is liberated very quickly, alkali metals</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>more reactive going down group so Cs, near bottom, extremely reactive,</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>U.I. turns purple as strongly alkaline CsOH(aq) formed in reaction</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2Cs(s) + 2H₂O(l) → 2CsOH(aq) + H₂(g)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Marks</td>
<td>Guidance</td>
</tr>
<tr>
<td>-----------------</td>
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</tr>
</tbody>
</table>
| 4               | **Method A** – any three from:  
• add water to mixture,  
• stir and filter,  
• S insoluble in water so left as residue on filter paper,  
• wash S with distilled water to remove impurities then leave to dry,  
• evaporate NaNO₃ solution  
• by heating on water bath until point of crystallisation,  
• leave to dry, crystallising NaNO₃  
**Method B** – any three from:  
• add xylene to mixture,  
• stir and filter,  
• NaNO₃ insoluble in xylene so left as residue on filter paper,  
• wash NaNO₃ with xylene and leave to dry,  
• evaporate xylene from filtrate of S solution  
• by warming on water bath (electrically heated / no naked flame)  
• in fume cupboard to crystallise S | 3 | 3 |
## C2.4 Group 7 – the halogens

<table>
<thead>
<tr>
<th>Question number</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1 a</td>
<td>melting points increase</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1 b</td>
<td>reactivity decreases</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2 a</td>
<td>gas: F, Cl; liquid: Br; solid: I, At</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2 b</td>
<td>halogens</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3 a</td>
<td>Li⁺ = 2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F⁻ = 2, 8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3 b</td>
<td>share a pair of electrons (one from each atom)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4 a</td>
<td>2Na(s) + I₂(g) → 2NaI(s)</td>
<td>3</td>
<td>1 mark for correct reactants. 1 mark for correct products. 1 mark for correct state symbols.</td>
</tr>
<tr>
<td>4 b</td>
<td>Cl₂(aq) + 2NaI(aq) → 2NaCl(aq) + I₂(aq)</td>
<td>3</td>
<td>1 mark for correct reactants. 1 mark for correct products. 1 mark for correct state symbols.</td>
</tr>
<tr>
<td>5</td>
<td>colourless solution of NaI turns red/brown as bromine added, bromine displaces iodide ions from solution, forming (colourless) aqueous bromide ions and leaving red / brown iodine molecules in solution as bromine more reactive than iodine</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Br₂(aq) + 2NaI(aq) → 2NaBr(aq) + I₂(aq)</td>
<td>1</td>
<td></td>
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</tbody>
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## C2.5 Explaining trends

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<tr>
<td>1</td>
<td>helium, although smallest positive charge on He nucleus, outer electrons nearest to nucleus, no inner shells of electrons shielding nuclear charge</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>electron in outermost shell less strongly attracted to nucleus than in Li, greater distance between outer electron and nucleus → attraction in K weaker, more inner shells shield outer electron in K, so K loses outer electron more easily</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>going down group, outermost shell further from attractive force of nucleus so harder for Br atom to gain electron, outer shell in Br shielded by more inner shells, reducing attraction between electron and nucleus so Br less reactive than F</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4 a</td>
<td>Ca more reactive than Mg, Group 2 elements more reactive going down group, atoms react by losing two outer shell electrons, easier to lose because greater distance between nucleus and outer electrons, greater shielding effect in Ca compared with Mg</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td></td>
<td></td>
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<tr>
<td>-----------------</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>4 b</td>
<td>O more reactive than S, Group 6 non-metals less reactive going down group, atoms react by gaining two electrons, harder for S atoms than O atoms, as in sulfur outer shell further from attractive force of nucleus, shielded by more electron shells</td>
<td></td>
<td></td>
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</tbody>
</table>

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<thead>
<tr>
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<tbody>
<tr>
<td>1</td>
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<td>1</td>
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</tbody>
</table>
## C2.6 The transition elements

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</tr>
</thead>
<tbody>
<tr>
<td>1 a</td>
<td>electric conductors, thermal conductors, hard and strong, high densities, high melting points</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1 b</td>
<td>lower melting point</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2 a</td>
<td>iron(II) chloride</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2 b</td>
<td>chromium(III) oxide</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2 c</td>
<td>manganese(II) bromide</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2 d</td>
<td>nickel(II) carbonate</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>copper(I) oxide, Cu$_2$O, copper(II) oxide, CuO</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>vanadium(V) oxide, V$_2$O$_5$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>catalyst in oxidation of SO$_2$ to SO$_3$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>vanadium changes the charge on its ion / oxidation state, in this case from 5$^+$ to 4$^+$ (forming vanadium(IV) oxide)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>when SO$_2$ is converted to SO$_3$, then changes back to 5$^+$ by reacting with oxygen to reform V$_2$O$_5$ catalyst</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>