# Cambridge International AS & A Level Chemistry

**CHAPTER 1**

Atomic Structure

**9701/1 & 9701/2**

**Mark Scheme**

**BOOKLET SUMMARY**

- Mark Scheme

**INFORMATION**

- This booklet (version 01) is designed by Vince Hoor © 2024.
- The PDF copy of this booklet is available in the Google Classroom.

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A-Level Chemistry Tuition Penang – by Mr. Hoor

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This document has 16 printed pages. Any blank pages are indicated.

## Tutorial Questions

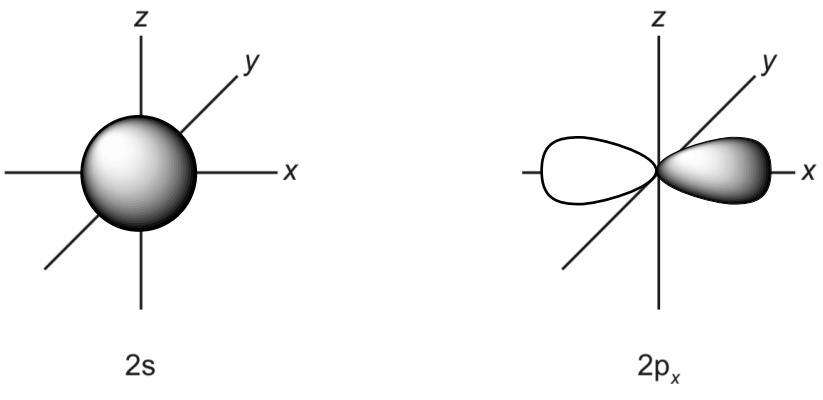
### Section A

| Question | Answer | Question | Answer | Question | Answer |
|---|---|---|---|---|---|
| 1 | A | 26 | B | 51 | D |
| 2 | D | 27 | D | 52 | A |
| 3 | B | 28 | C | 53 | A |
| 4 | A | 29 | D | 54 | C |
| 5 | B | 30 | A | 55 | C |
| 6 | B | 31 | C | 56 | A |
| 7 | D | 32 | B | 57 | D |
| 8 | B | 33 | D | 58 | C |
| 9 | C | 34 | D | 59 | C |
| 10 | A | 35 | D | 60 | D |
| 11 | A | 36 | C | 61 | C |
| 12 | C | 37 | A | 62 | B |
| 13 | D | 38 | D | 63 | D |
| 14 | D | 39 | B | 64 | A |
| 15 | C | 40 | C | | |
| 16 | D | 41 | C | | |
| 17 | B | 42 | B | | |
| 18 | D | 43 | C | | |
| 19 | C | 44 | B | | |
| 20 | B | 45 | B | | |
| 21 | D | 46 | D | | |
| 22 | D | 47 | B | | |
| 23 | B | 48 | B | | |
| 24 | C | 49 | B | | |
| 25 | B | 50 | C | | |

## Section B

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(a)(i)</td><td>left : (+), right : (–)</td><td>1</td></tr>
<tr><td>1(a)(ii)</td><td>beam of neutrons shown in a straight line without deflection</td><td>1</td></tr>
<tr><td>1(b)</td><td>same number of protons<br>different number of neutrons</td><td>1</td></tr>
<tr><td>1(c)</td><td><table><tr><th>isotope</th><th>protons</th><th>neutrons</th><th>electrons</th></tr><tr><td>$^{69}$Ga</td><td>31</td><td>38</td><td>31</td></tr><tr><td>$^{71}$Ga</td><td>31</td><td>40</td><td>31</td></tr></table>1 mark for each correct row</td><td>2</td></tr>
<tr><td>1(d)</td><td><table><tr><th>name of element</th><th>nucleon number</th><th>atomic number</th><th>protons</th><th>neutrons</th><th>electrons</th><th>overall charge</th></tr><tr><td>lithium</td><td>6</td><td>3</td><td>3</td><td>3</td><td>2</td><td>+1</td></tr><tr><td>oxygen</td><td>17</td><td>8</td><td>8</td><td>9</td><td>10</td><td>–2</td></tr><tr><td>iron</td><td>54</td><td>26</td><td>26</td><td>28</td><td>24</td><td>+2</td></tr><tr><td>chlorine</td><td>35</td><td>17</td><td>17</td><td>18</td><td>17</td><td>0</td></tr></table>1 mark for each correct row</td><td>4</td></tr>
<tr><td>1(e)</td><td><table><tr><th>name of element</th><th>nucleon number</th><th>atomic number</th><th>protons</th><th>neutrons</th><th>electrons</th><th>overall charge</th></tr><tr><td>boron</td><td>10</td><td>5</td><td>5</td><td>5</td><td>5</td><td>0</td></tr><tr><td>nitrogen</td><td>15</td><td>7</td><td>7</td><td>8</td><td>10</td><td>–3</td></tr><tr><td>lead</td><td>208</td><td>82</td><td>82</td><td>126</td><td>80</td><td>+2</td></tr><tr><td>lithium</td><td>6</td><td>3</td><td>3</td><td>3</td><td>2</td><td>+1</td></tr></table>1 mark for each correct row</td><td>4</td></tr>
<tr><td>1(f)</td><td><table><tr><th>molecular ion</th><th>total number of protons</th><th>total number of electrons</th></tr><tr><td>$NH_4^+$</td><td>11</td><td>10</td></tr><tr><td>$CO_3^{2-}$</td><td>30</td><td>32</td></tr><tr><td>$PO_4^{3-}$</td><td>47</td><td>50</td></tr></table>1 mark for each correct row</td><td>3</td></tr>
</table>

| Question | Answer | Marks |
|---|---|---|
| 2(a)(i) | atom of the same element with the same proton number but different number of neutrons | **1** |
| 2(a)(ii) | protons = 12, neutrons = 13 | **1** |
| 2(a)(iii) | $1s^2\ 2s^2\ 2p^6\ 3s^2$ | **1** |
| 2(b) | similarity: they have same chemical properties because they have the same number of electrons.<br><br>difference: they have different physical properties because they have different mass number / number of neutrons | **2** |
| 2(c) | **M1** atomic number = 29 **AND** nucleon number = 65<br>**M2** number of neutrons = 65 – 29 = 36<br>**M3** electronic configuration = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$ | **3** |

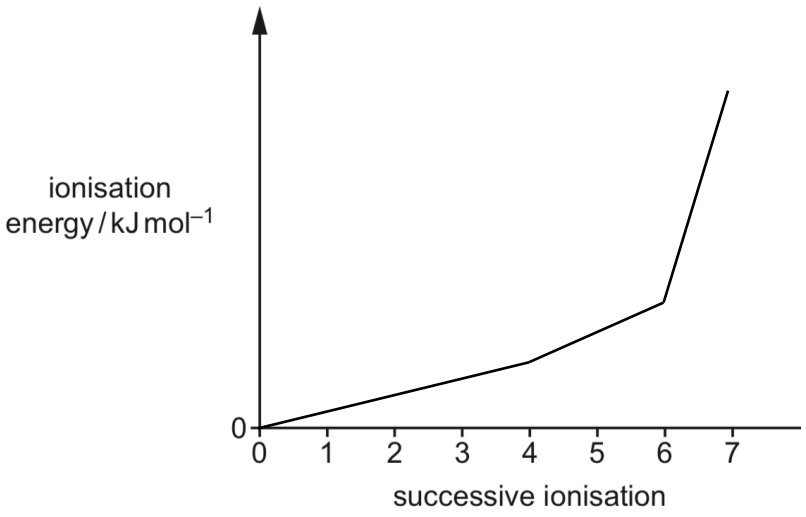
| Question | Answer | Marks |
|---|---|---|
| 3(a) |  | **2** |

<table>
<tr><td>3(b)</td><td>4s and correct s orbital shown</td><td>1</td></tr>
<tr><td>3(c)(i)</td><td>
<table>
<tr><td>1s</td><td>2s</td><td colspan="3">2p</td></tr>
<tr><td>⇅</td><td>⇅</td><td>⇅</td><td>⇅</td><td>1</td></tr>
</table>
</td><td>1</td></tr>
<tr><td>3(c)(ii)</td><td>lowest energy orbital = 1s AND number of unpaired electron = 1</td><td>1</td></tr>
<tr><td>3(d)(i)</td><td>
<table>
<tr><td>type of orbital</td><td>s</td><td>p</td><td>d</td></tr>
<tr><td>number of orbitals</td><td>4</td><td>9</td><td>5</td></tr>
</table>
</td><td>3</td></tr>
<tr><td>3(d)(ii)</td><td>
<table>
<tr><td>1s</td><td>2s</td><td colspan="3">2p</td><td>3s</td><td colspan="2">3p</td><td>4s</td></tr>
<tr><td>⇅</td><td>⇅</td><td>⇅</td><td>⇅</td><td>⇅</td><td>⇅</td><td>1</td><td>1</td><td></td></tr>
</table>
</td><td>2</td></tr>
<tr><td>3(d)(iii)</td><td>5</td><td>1</td></tr>
<tr><td>3(e)</td><td>
<table>
<tr><td>full electronic configuration</td><td>shorthand electronic configuration</td></tr>
<tr><td>$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$</td><td>[Ar] $3d^{10}\ 4s^1$</td></tr>
</table>
</td><td>2</td></tr>
<tr><td>3(f)</td><td>
<table>
<tr><td></td><td></td><td colspan="5">3d</td><td>4s</td></tr>
<tr><td>Fe</td><td>[Ar]</td><td>⇅</td><td>1</td><td>1</td><td>1</td><td>1</td><td>⇅</td></tr>
<tr><td>$Fe^{3+}$</td><td>[Ar]</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td></td></tr>
</table>
</td><td>2</td></tr>
<tr><td>3(g)</td><td>
<table>
<tr><td></td><td></td><td colspan="5">3d</td><td>4s</td></tr>
<tr><td>Cr</td><td>[Ar]</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>$Cr^{3+}$</td><td>[Ar]</td><td>1</td><td>1</td><td>1</td><td></td><td></td><td></td></tr>
</table>
</td><td>2</td></tr>
<tr><td>3(h)(i)</td><td>$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$</td><td>1</td></tr>
<tr><td>3(h)(ii)</td><td>9</td><td>1</td></tr>
<tr><td>3(h)(iii)</td><td>5s</td><td>1</td></tr>
</table>

| Question | Answer | Marks |
|---|---|---|
| 4(a) | energy needed to remove an electron;<br>from each atom in one mole of gaseous atoms | **2** |
| 4(b)(i) | $Na(g) \rightarrow Na^{+}(g) + e^{-}$ | **1** |
| 4(b)(ii) | $Be^{+}(g) \rightarrow Be^{2+}(g) + e^{-}$ | **1** |
| 4(b)(iii) | $A\ell^{2+}(g) \rightarrow A\ell^{3+}(g) + e^{-}$ | **1** |
| 4(c) | nuclear charge **AND** shielding effect (experienced by outer electrons) | **1** |
| 4(d)(i) | Li has lower nuclear charge than Na;<br>Li has lower shielding effect than Na;<br>Li has stronger nuclear attraction to the outer electron | **2** |
| 4(d)(ii) | Mg has greater nuclear charge than Na;<br>Mg has stronger nuclear attraction to the outer electrons compared to Na | **2** |
| 4(e) | nuclear charge increases across the Period;<br>shielding effect remains almost constant;<br>nuclear attraction to the outer electron increases | **3** |
| 4(f) | number of filled electron shell increases down the group;<br>shielding effect increases;<br>nuclear attraction to the outer electron decreases | **3** |

| Question | Answer | Marks |
|---|---|---|
| 5(a)(i) | $H(g) \rightarrow H^+(g) + e^-$ | **1** |
| 5(a)(ii) | H atom has only 1 electron | **1** |
| 5(a)(iii) | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ | **1** |
| 5(b)(i) | $Li^+(g) \rightarrow Li^{2+}(g) + e^-$ | **1** |
| 5(b)(ii) | second electron is removed from inner shell / orbitals with lower energy level;<br>the electron is subject to stronger nuclear attraction | **2** |
| 5(c) | second electron is removed from smaller $C^+$ ion;<br>the electron is subject to stronger nuclear attraction | **2** |
| 5(d)(i) | 3p | **1** |
| 5(d)(ii) | O has lower nuclear charge than S;<br>O has lower shielding effect than S;<br>overall there is stronger nuclear attraction to outer electron for O<br><br>1 mark for 2 correct points, 2 marks for 3 correct points | **2** |
| 5(e)(i) | 1400 | **1** |
| 5(e)(ii) | N has greater nuclear than C;<br>N has stronger nuclear attraction to outer electron;<br>O has lower first IE than N due to spin-pair repulsion on one 2p orbital;<br>this outweighs the increasing nuclear charge of O | **4** |

| Question | Answer | Marks |
|---|---|---|
| 6(a) | full electronic configuration = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$;<br>there is a large increase after 3rd IE;<br>this indicates that E has three outer electrons | **3** |
| 6(b) | Group 16 and there is a large increases after 6th IE | **1** |
| 6(c) | there is a large increase after 1st IE;<br>this indicates that K has one outer electron / second electron is removed from inner shell | **2** |
| 6(d)(i) | Group 16;<br>there is a large increase after sixth ionisation energy | **2** |
| 6(d)(ii) | there is a spin-pair repulsion between paired electrons in one 3p orbital of **Y**;<br>this outweighs the increasing nuclear charge of **Y** | **2** |
| 6(d)(iii) | atomic radius decreases from X > Y > Z;<br>due to increasing nuclear charge and shielding effect remains constant;<br>overall there is stronger nuclear attraction to the outer electrons | **3** |
| 6(e)(i) | first electron to be removed from Al is from 3p orbital;<br>3p orbital is slightly further away from the nucleus than 3s / 3p orbital is in the higher energy level than 3s / 3p orbital is slightly more shielded than 3s orbital | **2** |
| 6(e)(ii) | there is a spin-pair repulsion between paired electrons in one 3p orbital of S;<br>this outweighs the increasing nuclear charge of S | **2** |
| 6(f) | Both $Al^{2+}$ and Na have the same electronic configuration;<br>$Al^{2+}$ has greater nuclear and stronger nuclear attraction to the outer electron | **2** |

| Question | Answer | Marks |
|---|---|---|
| 7(a) | nucleon number = 130,<br>neutrons = 52,<br>electrons = 78 | **3** |
| 7(b) | 1s | **1** |
| 7(c) | $Te(g) \rightarrow Te^{+}(g) + e^{-}$ | **1** |
| 7(d)(i) | increasing nuclear attraction to the outer electrons;<br>decreasing shielding effect as electrons are continuously removed | **2** |
| 7(d)(ii) |  | **2** |

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>8(a)(i)</td><td>
<table>
<tr><td>property</td><td>P</td><td>S</td><td>Cl</td></tr>
<tr><td>number of electrons in 3p subshell</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>total number of unpaired electrons</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>first ionisation energy / kJ mol$^{-1}$</td><td>1060</td><td></td><td>1260</td></tr>
<tr><td>formula of most common anion</td><td>$P^{3-}$</td><td>$S^{2-}$</td><td>$Cl^-$</td></tr>
</table>
1 mark for each correct row
</td><td>2</td></tr>
<tr><td>8(a)(ii)</td><td>$P(g) \rightarrow P^+(g) + e^-$</td><td>1</td></tr>
<tr><td>8(a)(iii)</td><td>1000 kJ mol$^{-1}$;<br>Cl has greater nuclear charge than both S and P;<br>Cl has stronger nuclear attraction to the outer electron;<br>there is spin-pair repulsion between paired electrons in one 3p orbital of S;<br>this outweighs the increasing nuclear charge of S.</td><td>4</td></tr>
<tr><td>8(b)(i)</td><td>$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$</td><td>1</td></tr>
<tr><td>8(b)(ii)</td><td>ionic radius decreases from $P^{3-} > S^{2-} > Cl^-$;<br>nuclear charge increases from P to S to Cl;<br>shielding effect remains almost constant;<br>overall there is stronger nuclear attraction to the outer electrons</td><td>2</td></tr>
</table>