IB SL Topic 2 EQ Paper 2 Section A & Section B 16w to 99s 160 marks

Before 2016 paper 2 was included 4 section B questions, of which you had to chose 2. After 2016 all questions became compulsory on Paper 2.
All topics ranked according to their impact on your final grade using exam papers from 1999 to 2016

| TOPICS and IA | IA | 10 | Option | N.ofSci | 4 | 5 | 8 | 3 | 1 | 9 | 7 | 6 | 2 | 11 |
|---------------|----|----|--------|---------|---|---|---|---|---|---|---|---|---|---|---|
| Paper 1       | 12.8 | 14.8 | 10.2 | 7.1 | 8.5 | 14.8 | 8.2 | 6.0 | 6.8 | 4.8 | 6.0 |
| Paper 2 16 to 08 | 23.5 | 10.9 | 10.3 | 9.8 | 5.1 | 6.8 | 11.4 | 7.1 | 7.5 | 7.0 | 0.7 |
| Paper 2 07 to 99 | 21.4 | 12.6 | 9.8 | 12.1 | 12.5 | 4.1 | 5.9 | 9.5 | 7.3 | 4.9 | 0.0 |
| Paper 2 ALL   | 22.4 | 11.8 | 10.0 | 10.9 | 8.8 | 5.5 | 8.6 | 8.3 | 7.4 | 6.0 | 0.3 |
| Paper 3       | 0.0 | 0.0 | 57.1 | 42.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total % All Marks, Weighted | 20 | 11.5 | 11.4 | 8.6 | 7.7 | 6.1 | 5.8 | 5.2 | 5.1 | 5.1 | 4.5 | 4.3 | 3.4 | 1.3 |
| Rank Order    | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |

Essentially, Nature of Science (NoS) is almost half of the paper, sections after 6, so 7, 8 & 10 are only found in HL. This is older data and will be updated in late 2019 (I stopped teaching IB in 2016, teaching A levels instead and started again in the second half of 2019).
Standard and Higher Level components compared

<table>
<thead>
<tr>
<th>IA</th>
<th>Option</th>
<th>10</th>
<th>9/8/7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.0</td>
<td>11.5</td>
<td>11.1</td>
<td>8.6</td>
<td>7.7</td>
<td>6.1</td>
<td>5.8</td>
<td>5.2</td>
<td>5.1</td>
<td>4.5</td>
<td>4.3</td>
</tr>
<tr>
<td>20.0</td>
<td>11.5</td>
<td>11.1</td>
<td>8.6</td>
<td>7.7</td>
<td>6.1</td>
<td>5.8</td>
<td>5.2</td>
<td>5.1</td>
<td>4.5</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Essentially, IA has the exact same weight, the Option in HL is almost 50% more important than in SL but Topic 10 is more important in SL than HL. All other topics contribute almost equally to a SL and HL grade.
The dark blue bars are where your final IB grade will be from:

1. Your IA is the single most important part of your IB SL, more important than even the Option. Imagine how much time in class, at home and in revision you have or will
give to topics 9, 10 and 11. Your IA, on average, will be worth more to your final grade than all those combined.
2. The Option is the most important topic for your IB grade compared to the everything else
3. Topic 10, Organic Chemistry, is by far the most important topic for papers 1 and 2.

<table>
<thead>
<tr>
<th>Topic Number</th>
<th>% of Marks awarded for each topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.1</td>
</tr>
<tr>
<td>2</td>
<td>3.4</td>
</tr>
<tr>
<td>3</td>
<td>5.2</td>
</tr>
<tr>
<td>4</td>
<td>7.7</td>
</tr>
<tr>
<td>5</td>
<td>6.1</td>
</tr>
<tr>
<td>6</td>
<td>4.3</td>
</tr>
<tr>
<td>7</td>
<td>4.5</td>
</tr>
<tr>
<td>8</td>
<td>5.8</td>
</tr>
<tr>
<td>9</td>
<td>5.1</td>
</tr>
<tr>
<td>10</td>
<td>11.5</td>
</tr>
<tr>
<td>11</td>
<td>1.3</td>
</tr>
<tr>
<td>12</td>
<td>11.4</td>
</tr>
<tr>
<td>13</td>
<td>8.6</td>
</tr>
<tr>
<td>14</td>
<td>20.0</td>
</tr>
</tbody>
</table>

*Stats from exam papers from 1999 through to winter 2016.*
**Essential idea:** The mass of an atom is concentrated in its minute, positively charged nucleus.

## 2.1 The nuclear atom

### Nature of science:
Evidence and improvements in instrumentation—alpha particles were used in the development of the nuclear model of the atom that was first proposed by Rutherford. (1.8)
Paradigm shifts—the subatomic particle theory of matter represents a paradigm shift in science that occurred in the late 1800s. (2.3)

### Understandings:
- Atoms contain a positively charged dense nucleus composed of protons and neutrons (nucleons).
- Negatively charged electrons occupy the space outside the nucleus.
- The mass spectrometer is used to determine the relative atomic mass of an element from its isotopic composition.

### Applications and skills:
- Use of the nuclear symbol notation $^{\text{A}}_{\text{Z}}$ to deduce the number of protons, neutrons, and electrons in atoms and ions.
- Calculations involving non-integer relative atomic masses and abundance of isotopes from given data, including mass spectra.

### Guidance:
- Relative masses and charges of the subatomic particles should be known, actual values are given in section 4 of the data booklet. The mass of the electron can be considered negligible.
- Specific examples of isotopes need not be learned.
- The operation of the mass spectrometer is not required.

### International-mindedness:
- Isotope enrichment uses physical properties to separate isotopes of uranium, and is employed in many countries as part of nuclear energy and weaponry programmes.

### Theory of knowledge:
- Richard Feynman: “If all of scientific knowledge were to be destroyed and only one sentence passed on to the next generation, I believe it is that all things are made of atoms.” Are the models and theories which scientists create accurate descriptions of the natural world, or are they primarily useful interpretations for prediction, explanation, and control of the natural world?
- No subatomic particles can be (or will be) directly observed. Which ways of knowing do we use to interpret indirect evidence, gained through the use of technology?

### Utilization:
- Radioisotopes are used in nuclear medicine for diagnostics, treatment and research, as tracers in biochemical and pharmaceutical research, and as "chemical clocks" in geological and archaeological dating.
- PET (positron emission tomography) scanners give three-dimensional images of tracer concentration in the body, and can be used to detect cancers.

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**Syllabus and cross-curricular links:**
Topics 11.3, 21.1 and options D.8 and D.9—NMR
Options C.3 and C.7—nuclear fission
Option D.8—nuclear medicine

**Aims:**
- **Aim 7:** Simulations of Rutherford's gold foil experiment can be undertaken.
- **Aim 8:** Radionuclides carry dangers to health due to their ionizing effects on cells.
4. Magnesium is a group 2 metal which exists as a number of isotopes and forms many compounds.

(a) State the nuclear symbol notation, \( \frac{2}{12}X \), for magnesium-26. [1]

(b) Mass spectroscopic analysis of a sample of magnesium gave the following results:

<table>
<thead>
<tr>
<th>Isotope</th>
<th>% Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mg-24</td>
<td>78.60</td>
</tr>
<tr>
<td>Mg-25</td>
<td>10.11</td>
</tr>
<tr>
<td>Mg-26</td>
<td>11.29</td>
</tr>
</tbody>
</table>

Calculate the relative atomic mass, \( A_r \), of this sample of magnesium to two decimal places. [2]

Q# 2/ IB Chem/2016/SP/TZ0/Paper 2 Section A/Standard Level/Q1

(d) (i) State the condensed electron configuration of sulfur. [1]

(ii) Deduce the orbital diagram of sulfur, showing all the orbitals present in the diagram. [1]
Q# 3/ IB Chem/2016/s/TZ0/Paper 2 Section A/Standard Level/Q4(c)

(ii) State the structure of the nucleus and the orbital diagram of $^{13}$C in its ground state. [2]

<table>
<thead>
<tr>
<th>No. protons</th>
<th>No. neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Orbital diagram

```
1s  2s  2p
```

(d) Draw a 1s atomic orbital and a 2p atomic orbital. [1]

1s: 2p:

Q# 4/ IB Chem/2013/s/tz1/Paper 2 Section B/Standard Level/

6. The element boron has two naturally occurring isotopes, $^{10}$B and $^{11}$B.

(a) (i) Define the term isotopes of an element. [1]

(ii) Calculate the percentage abundance of each isotope, given that the relative atomic mass of B is 10.81. [2]
(b) The percentage abundance of the isotopes of boron can be determined with a mass spectrometer. The diagram shows the operation of a mass spectrometer.

$^{11}\text{B}$ is converted into $^{11}\text{B}^+$ in stage Q

(ii) Deduce the number of protons, neutrons and the electron arrangement of the main ion of $^{11}\text{B}$ formed in stage Q. \[2\]  

<table>
<thead>
<tr>
<th>Protons:</th>
</tr>
</thead>
<tbody>
<tr>
<td>...........................................................................................................</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Neutrons:</th>
</tr>
</thead>
<tbody>
<tr>
<td>...........................................................................................................</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electron arrangement:</th>
</tr>
</thead>
<tbody>
<tr>
<td>...........................................................................................................</td>
</tr>
</tbody>
</table>

(iii) Identify the species that is used as the scale for the mass of the isotopes. \[1\]

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>.................................................................................................</td>
</tr>
</tbody>
</table>
4. Lithium and boron are elements in period 2 of the periodic table. Lithium occurs in group 1 (the alkali metals) and boron occurs in group 3. Isotopes exist for both elements.

(a) (i) Define the terms **atomic number**, **mass number** and **isotopes of an element**.  

Atomic number:
..................................................................................  
..................................................................................  
..................................................................................

Mass number:
..................................................................................
..................................................................................
..................................................................................

Isotopes of an element:
..................................................................................
..................................................................................
..................................................................................

(iii) Deduce the electron arrangements of the lithium ion, Li⁺, and the boron atom, B.  

Li⁺: ..................................................................................  

B: ..................................................................................

(iv) Naturally occurring boron exists as two isotopes with mass numbers of 10 and 11. Calculate the percentage abundance of the lighter isotope, using this information and the relative atomic mass of boron in Table 5 of the Data Booklet.  

..................................................................................
..................................................................................
..................................................................................
..................................................................................
(v) Lithium exists as two isotopes with mass numbers of 6 and 7. Deduce the number of protons, electrons and neutrons for each isotope.

<table>
<thead>
<tr>
<th>Mass number (A)</th>
<th>Number of protons</th>
<th>Number of electrons</th>
<th>Number of neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) Every element has its own unique line emission spectrum.

(i) Distinguish between a *continuous spectrum* and a *line spectrum*.

(ii) Draw a diagram to show the electron transitions between energy levels in a hydrogen atom that are responsible for the two series of lines in the ultraviolet and visible regions of the spectrum. Label your diagram to show three transitions for each series.
Q# 6/ IB Chem/2011s q7 /Paper 2 Section A/Standard Level/

(f) Silicon has three stable isotopes, $^{28}$Si, $^{29}$Si and $^{30}$Si. The heaviest isotope, $^{30}$Si, has a percentage abundance of 3.1%. Calculate the percentage abundance of the lightest isotope to one decimal place.

Q# 7/ IB Chem/2011w/TZ0/Paper 2 Section A/Standard Level/

2. Isotopes are atoms of the same element with different mass numbers. Two isotopes of cobalt are Co-59 and Co-60.

(a) Deduce the missing information and complete the following table.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>$^{59}$Co$^{2+}$</th>
<th>$^{60}$Co</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of protons</td>
<td>27</td>
<td>53</td>
</tr>
<tr>
<td>Number of neutrons</td>
<td>33</td>
<td>72</td>
</tr>
<tr>
<td>Number of electrons</td>
<td>27</td>
<td>53</td>
</tr>
</tbody>
</table>

Q# 8/ IB Chem/2011s/TZ1/Paper 2 Section A/Standard Level/

2. (a) Explain why the relative atomic mass of argon is greater than the relative atomic mass of potassium, even though the atomic number of potassium is greater than the atomic number of argon.

(b) Deduce the numbers of protons and electrons in the K$^+$ ion.
Q# 9/ IB Chem/2010/w/TZ0/Paper 2 Section A/Standard Level/
3. Iron has three main naturally occurring isotopes which can be investigated using a mass spectrometer.
   (b) A sample of iron has the following isotopic composition by mass.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>$^{54}$Fe</th>
<th>$^{56}$Fe</th>
<th>$^{57}$Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative abundance / %</td>
<td>5.95</td>
<td>91.88</td>
<td>2.17</td>
</tr>
</tbody>
</table>

Calculate the relative atomic mass of iron based on this data, giving your answer to two decimal places.

Q# 10/ IB Chem/2010/s/tz1/Paper 2 Section B/Standard Level/
4. (a) Define the term relative atomic mass ($A_r$).

(b) Relative atomic masses are obtained using a mass spectrometer. Draw a simple annotated diagram of the mass spectrometer.

(c) The relative atomic mass of naturally occurring copper is 63.55. Calculate the abundances of $^{69}$Cu and $^{65}$Cu in naturally occurring copper.

Q# 11/ IB Chem/2009/s/tz1/Paper 2 Section B/Standard Level/Q5 a
3. Strontium exists as four naturally-occurring isotopes. Calculate the relative atomic mass of strontium to two decimal places from the following data.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Percentage abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sr-84</td>
<td>0.56</td>
</tr>
<tr>
<td>Sr-86</td>
<td>9.90</td>
</tr>
<tr>
<td>Sr-87</td>
<td>7.00</td>
</tr>
<tr>
<td>Sr-88</td>
<td>82.54</td>
</tr>
</tbody>
</table>
Q# 12/ IB Chem/2008/w/TZ0/Paper 2 Section A/Standard Level/
2. (a) Define the term *isotopes*. [2]

(b) A sample of krypton contains these isotopes.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Percentage abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>^{82}Kr</td>
<td>15.80</td>
</tr>
<tr>
<td>^{84}Kr</td>
<td>65.40</td>
</tr>
<tr>
<td>^{86}Kr</td>
<td>18.80</td>
</tr>
</tbody>
</table>

(i) Calculate the relative atomic mass of krypton in this sample. Give your answer to two decimal places. [2]

(ii) Deduce the number of each sub-atomic particle in an atom of ^{84}Kr. [2]

Protons ........................................
Neutrons .......................................
Electrons ......................................

Q# 13/ IB Chem/2008/s/TZ1/Paper 2 Section A/Standard Level/
2. (a) In a sample of gallium, the percentage abundance of ^{69}Ga is 60.4 and ^{71}Ga is 39.6. Determine the relative atomic mass of gallium. [2]

(b) State the electron arrangement of the following species. [2]

(i) A potassium ion
(ii) A sulfide ion

(c) Describe the difference between a continuous spectrum and a line spectrum. [2]

Q# 14/ IB Chem/2007/w/TZ0/Paper 2 Section A/Standard Level/

2. Naturally occurring copper has a relative atomic mass (A_r) of 63.55 and consists of two isotopes 63\text{Cu} and 65\text{Cu}.

(a) Define the term relative atomic mass, A_r. [1]

(b) State and explain which is the more abundant isotope. [1]

(c) Describe and explain how the physical and chemical properties of the two isotopes compare. [4]

Q# 16/ IB Chem/2007/s/tz1/Paper 2 Section B/Standard Level/q6

(f) The relative atomic mass of chlorine is 35.45. Calculate the percentage abundance of the two isotopes of chlorine, ^35\text{Cl} and ^37\text{Cl} in a sample of chlorine gas. [2]
Q# 17/ IB Chem/2006wQ3
(b) State the electron arrangements of the following species: [2]

Si .................................................................
P^3- ....................................................................

(c) Identify the numbers of protons, neutrons and electrons in the species \(^{32}\text{S}^{2-}\). [1]

.................................................................

.................................................................

Q# 18/ IB Chem/2006/s/TZ1/Paper 2 Section A/Standard Level/

2. (a) Define the following terms.

(i) atomic number [1]

.................................................................

.................................................................

(ii) mass number [1]

.................................................................

.................................................................

(b) Use the data below to calculate the relative molecular mass of thallium bromide, \(\text{TIBr}_2\), to two decimal places. [3]

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Percentage Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(^{201}\text{Tl})</td>
<td>29.52</td>
</tr>
<tr>
<td>(^{205}\text{Tl})</td>
<td>70.48</td>
</tr>
<tr>
<td>(^{79}\text{Br})</td>
<td>50.69</td>
</tr>
<tr>
<td>(^{81}\text{Br})</td>
<td>49.31</td>
</tr>
</tbody>
</table>

.................................................................

.................................................................

(c) Write the symbol for the ion with a 2+ charge which has the electron arrangement of 2, 8. [1]

.................................................................
(d) Write the symbols for three other species, which also have the electron arrangement of 2, 8.

.................................................................

.................................................................

.................................................................

Q# 19/ IB Chem/2005/w/TZ0/Paper 2 Section A/Standard Level/

3. The element bromine exists as the isotopes $^{79}\text{Br}$ and $^{81}\text{Br}$, and has a relative atomic mass of 79.90.

(a) Complete the following table to show the numbers of sub-atomic particles in the species shown. [3]

<table>
<thead>
<tr>
<th></th>
<th>an atom of $^{79}\text{Br}$</th>
<th>an ion of $^{81}\text{Br}^-$</th>
</tr>
</thead>
<tbody>
<tr>
<td>protons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>neutrons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>electrons</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) State and explain which of the two isotopes $^{79}\text{Br}$ and $^{81}\text{Br}$ is more common in the element bromine. [1]

.................................................................

.................................................................

.................................................................

(c) The element calcium is in the same period of the Periodic Table as bromine.

(i) Write the electron arrangement for an atom of calcium. [1]

.................................................................

.................................................................

.................................................................

(ii) Deduce the formula of the compound calcium bromide. [1]

.................................................................

.................................................................

.................................................................

3. The element bromine exists as the isotopes $^{79}\text{Br}$ and $^{81}\text{Br}$, and has a relative atomic mass of 79.90.

(a) Complete the following table to show the numbers of sub-atomic particles in the species shown. [3]

<table>
<thead>
<tr>
<th></th>
<th>an atom of $^{79}\text{Br}$</th>
<th>an ion of $^{81}\text{Br}^-$</th>
</tr>
</thead>
<tbody>
<tr>
<td>protons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>neutrons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>electrons</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) State and explain which of the two isotopes $^{79}\text{Br}$ and $^{81}\text{Br}$ is more common in the element bromine. [1]

.................................................................

.................................................................

.................................................................
(c) The element calcium is in the same period of the Periodic Table as bromine.

(i) Write the electron arrangement for an atom of calcium.  

(ii) Deduce the formula of the compound calcium bromide.  

Q# 20/ IB Chem/2004/s/TZ1/Paper 2 Section A/Standard Level/

2. (a) Define the term isotope.  

(b) A sample of argon exists as a mixture of three isotopes.

    mass number 36, relative abundance 0.337 %
    mass number 38, relative abundance 0.0630 %
    mass number 40, relative abundance 99.6 %

Calculate the relative atomic mass of argon.  

(c) State the number of electrons, protons and neutrons in the ion $^{16}\text{F}^{-}\text{e}$.  

    electrons: ................ protons: ................ neutrons: ................

Q# 21/ IB Chem/2003/w/TZ0/Paper 2 Section A/Standard Level/

3. (a) State a physical property that is different for isotopes of an element.  

(b) Chlorine exists as two isotopes, $^{35}\text{Cl}$ and $^{37}\text{Cl}$. The relative atomic mass of chlorine is 35.45. Calculate the percentage abundance of each isotope.

    ...........................
    ...........................
    ...........................
Q# 22/ IB Chem/2002/w/TZ0/Paper 2 Section A/Standard Level/

2. Complete the following table. \[3\]

<table>
<thead>
<tr>
<th></th>
<th>Protons</th>
<th>Neutrons</th>
<th>Electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{27}$Al</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$^{24}$Mg$^{2+}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$^{16}$O$^{3-}$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q# 23/ IB Chem/2001/s/tz1/Paper 2 Section B/Standard Level/

5. (a) Describe the appearance of the emission spectrum of hydrogen. Explain how this spectrum is related to the electron energy levels of hydrogen. \[5\]

Q# 24/ IB Chem/2001/s/TZ1/Paper 2 Section A/Standard Level/

3. (a) Define the terms atomic number and mass number. \[2\]

Atomic number: .................................................................

..............................................................................

Mass number: .................................................................

..............................................................................

(b) For each of the species shown in the table, state the number of each sub-atomic particle present. \[3\]

<table>
<thead>
<tr>
<th>Species</th>
<th>Protons</th>
<th>Neutrons</th>
<th>Electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{14}$C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$^{19}$F$^{-}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$^{40}$Ca$^{2+}$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q# 25/ IB Chem/2000/w/tz0/Paper 2 Section B/Standard Level/

5. (a) State the meaning of the term mass number (A). State the difference between mass number and atomic number (Z). Show how these numbers can be used to determine the number and types of particles in an atom. \[4\]

(b) State the electronic configuration for a carbon atom. Calculate the number of protons, electrons and neutrons in a carbide ion, $^{12}$C$^{4+}$, and state their relative positions in the ion. \[4\]

(c) Chlorine consists of $^{35}$Cl and $^{37}$Cl atoms. If the relative atomic mass, $A_r$, of chlorine is 35.5, calculate the percentage of $^{35}$Cl in a sample, given $A_r(^{35}$Cl) = 35.0 and $A_r(^{37}$Cl) = 37.0. In terms of their electronic structure, state two ways in which atoms of $^{35}$Cl are similar to $^{37}$Cl. Besides the difference in the mass and the number of neutrons, state one way in which compounds containing $^{35}$Cl differ from compounds containing $^{37}$Cl atoms. \[4\]
Q# 26/ IB Chem/1999/s/tz1/Paper 2 Section B/Standard Level/

4. (a) A carbon atom has a mass number of 12 and an atomic number of 6. Define the underlined terms and draw a diagram showing clearly the arrangement of fundamental particles in this carbon atom.

(b) For each of the species listed below, state the number of protons, neutrons and electrons, and give the electronic configuration:

\[ ^{22}_{11}\text{Na}, \quad ^{29}_{19}\text{K}^+, \quad ^{35}_{17}\text{Cl}^- \]

(d) In addition to \(^{35}\text{Cl}\) there is another naturally occurring isotope of chlorine with a mass number of 37. If the relative atomic mass of chlorine is 35.5, state and explain which isotope is the more abundant.

(e) Part of the hydrogen spectrum is shown below.

\[
\text{line 1} \quad \text{line 2} \quad \text{line 3} \quad \text{line 4}
\]

\[
\text{decreasing wavelength}
\]

(i) State two features of the part of the spectrum that occur to the right of line 4.

(ii) What change in the hydrogen atom occurs to produce a line in the spectrum?

Mark Scheme IB SL Topic 2 EQ Paper 2 A & B 16w to 99s 160marks

Q# 1/ IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q4

<table>
<thead>
<tr>
<th>Question</th>
<th>Answers</th>
<th>Notes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. a</td>
<td>(^{24}\text{Mg}) ✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 4. b | \(
\begin{align*}
\text{v} &= \frac{24 \times 78.60 + 25 \times 10.11 + 26 \times 1.29}{100} \\
\text{v} &= 24.3269 \approx 24.33 \checkmark
\end{align*}
\) | Award [2] for correct final answer. Do not accept data booklet value (24.31). | 2 |

Q# 2/ IB Chem/2016/SP/TZ0/Paper 2 Section A/Standard Level/Q1

| d. i | \([\text{Na} ]^{3}\text{p}^+ \) ✓ | Electrons must be given as superscript. | 1 |
| d. ii | \(1\; 2s^2 \quad \quad 1\; 2s^2 \quad \quad 1\; 2s^2 \quad \quad 1\; 2s^2 \quad \quad 1\; 2s^2 \quad \quad 1\; 2s^2 \quad \quad 1\; 2p^6 \checkmark \) | | 1 |

Q# 3/ IB Chem/2016/s/TZ0/Paper 2 Section A/Standard Level/Q4

| 4. c. i | protons: 6 AND neutron: 7 ✓ | Accept full arrows. | 2 |
| 4. d. | 1s: AND 2p. ✓ | Accept p orbitals aligned on y- and z-axes, or diagrams correctly showing all three p-orbitals. Do not accept p orbitals without a node. | 1 |
Q# 4/ IB Chem/2013/s/tz1/Paper 2 Section B/Standard Level/

6. (a) (i) atoms of the same element with the same number of protons/with same atomic number but different number of neutrons/mass number/mass; [1]

(ii) \(10x + 11(1 - x) = 10.81\), \(x = 0.19\);

Accept similar method.

\(^{10}\text{B}\): 19% and \(^{11}\text{B}\): 81%; [2]

(b) (i) \(R\): acceleration and \(S\): deflection; [1]

(ii) Protons: 5 and Neutrons: 6;
Electron arrangement: \(2, 2, 2\); \(s^2\)
Allow suitable diagram.

(iii) \(^{12}\text{C}\)/carbon-12; [1]

Q# 5/ IB Chem/2012/w/tz0/Paper 2 Section B/Standard Level/

4. (a) (i) Atomic number:
number of protons (in nucleus/atom);

Mass number:
(sun of) number of protons and neutrons (in nucleus/atom);

Isotopes of an element:
atoms of same element / atoms with same number of protons/atomic number/\(Z\) but different number of neutrons/mass number/\(A\); [3]

Penalize once only use of the term element in the three definitions, for example, number of protons in an element or number of protons and neutrons in an element or element with the same atomic number but different mass number.

(iii) \(^{\text{Li}^+}\): \(2/1s^2\);
\(^{\text{B}}\): \(2.3/1s^2, 2s^2, 2p^1\); [2]

(iv) correct mathematical expression set-up (e.g. \(\frac{x}{100}(10) + \left[\frac{(100 - x)}{100}\right](11) = 10.81\));

19 %;

Award [2] for correct final answer. [2]

(v) 

<table>
<thead>
<tr>
<th>Mass number ((A))</th>
<th>Number of protons</th>
<th>Number of electrons</th>
<th>Number of neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
| 7                | 3                 | 3                  | 4                 | [2]

Award [1 max] for correct number of neutrons for both isotopes if numbers of protons or electrons is not given.

Award [1 max] for correct number of protons and electrons for both isotopes if number of neutrons is not given or if numbers of neutrons are incorrect.
(b) (i) **Continuous spectrum**: radiation spread over all wavelengths/frequencies/energies/colours / OWTTE;  
**Line spectrum**: radiation (absorbed/emitted) at certain/specific wavelengths/frequencies/energies/colours / OWTTE;  
Allow series of (separate/discrete) lines which converge/get closer together at high energy / OWTTE.  

(ii) 

\[ n = \infty \]

\[ n = 3 \]  
visible series

\[ n = 2 \]  
UV series

\[ n = 1 \]

showing y-axis labelled as energy/E or labelling at least two energy levels 
\((n = 1, n = 2 \text{ etc. but not for } n = 0)\);  
showing energy levels converging;  
showing jumps to \(n = 1\) for ultraviolet series;  
showing jumps to \(n = 2\) for visible series;  
**UV and visible must be labelled.**

Q# 6/ IB Chem/2011 sq7

(f) \(2809 = 3.10 \times 30 + 28x + 29(96.9 - x)\);  
\(\% ^{28}\text{Si} = (93 + 2810.1 - 2809) = 94.1 \%\);  
**Award [2] for correct final answer.**

(g) \(^{14}\text{C}\) and radiocarbon dating/(tracer in) medical/scientific tests;  
\(^{11}\text{C}\) and (tracer in) medical/scientific tests;  
**[1 max]**

Q# 7/ IB Chem/2011/w/TZ0/Paper 2 Section A/Standard Level/

2. (a) | Symbol | \(^{59}\text{Co}^{3+}\) | \(^{60}\text{Co}\) | \(^{125}\text{I}\) |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of protons</td>
<td>27</td>
<td>27</td>
<td>53</td>
</tr>
<tr>
<td>Number of neutrons</td>
<td>32</td>
<td>33</td>
<td>72</td>
</tr>
<tr>
<td>Number of electrons</td>
<td>24</td>
<td>27</td>
<td>53</td>
</tr>
</tbody>
</table>

**Award [2] for all four correct.**  
**Award [1] for two or three correct.**

(b) Co-60 emits (penetrating) gamma radiation/rays / OWTTE;  
**Allow because Co-60 emits radiation which kills/treats cancer cells.**  
**Do not allow answers such as Co-60 is radioactive or Co-60 treats cancer as single statements.**
2. (a) argon has a greater proportion of heavier isotopes / OWTTE / argon has a greater number of neutrons; [1]
(b) 19 protons and 18 electrons; [1]
(c) 2, 8, 8;
Accept 1s² 2s² 2p⁶ 3s² 3p⁶. [1]

Q# 9/ IB Chem/2010/w/TZ0/Paper 2 Section A/Standard Level/
3. (a) (i) ions/particles accelerated by electric field; ions/particles deflected by magnetic field; Award [1 max] for acceleration and deflection of ions without reference to fields. [2]
(ii) prevents collisions / avoid false readings due to presence of other particles; [1]
(b) \[
\frac{(54 \times 5.95) + (56 \times 91.88) + (57 \times 2.17)}{100} \]
55.90;
Award [2] for correct final answer.
Answer must be to 2 d.p. [2]
(c) 24; [1]

Q# 10/ IB Chem/2010/s/tz1/Paper 2 Section B/Standard Level/
4. (a) average mass of isotopes of an element compared to (1/12 g of) \(^{12}\text{C}\) / average mass of an atom relative to C–12 having a mass of exactly 12 / OWTTE. Allow element instead of atom.
Must refer to average mass and C–12. [1]
(b) Diagram of mass spectrometer containing in the correct sequence:
vaporization/vaporized sample;
ionization/electron gun;
acceleration/oppositely charged plates;
deflection/magnetic field;
detection.
Award [3] for 5 correct labels, [2] for 3–4 correct labels, [1] for 2 correct labels. Award [1] for correct order for at least 4 correct labels. Award [1] for diagram, which must at least show ionization (e.g. electron beam), acceleration (e.g. charged plates) and deflection (e.g. magnetic field) even if these are incorrectly labelled. [5]
(c) \[63x + 65(1–x) = 63.55; \]
(or some other mathematical expression).
\(^{63}\text{Cu} = 72.5\% \text{ and } ^{65}\text{Cu} = 27.5\%; \]
Allow \(^{65}\text{Cu} = 0.725 \text{ and } ^{65}\text{Cu} = 0.275.\] Award [2] for correct final answer. [2]
(d) \(^{60}\text{Co} / ^{31}\text{I} / ^{125}\text{T}.\] Must contain correct mass numbers. Allow other formats such as cobalt-60, Co-60 etc.
Award no marks if a correct radioisotope is given with an incorrect radioisotope. Allow any other radioisotope if you can verify its use. [1]

Q# 11/ IB Chem/2009/s/tz1/Paper 2 Section B/Standard Level/
5. (a) (i) a vaporized sample must be used; 
bombarded with (high energy) electrons to form positive ions; 
accelerated by passing through an electric field; 
deflected by passing through a magnetic field; 
detected by producing a current; 
Award [2 max] if just the words vaporization, ionization, acceleration, 
deflection and detection are used with no explanation. [5]

5. (a) (i) a vaporized sample must be used; 
bombarded with (high energy) electrons to form positive ions; 
accelerated by passing through an electric field; 
deflected by passing through a magnetic field; 
detected by producing a current; 
Award [2 max] if just the words vaporization, ionization, acceleration, 
deflection and detection are used with no explanation. [5]

(ii) (size of the positive) charge (on the ion); 
mass (of the ion); 
strength of the magnetic field; 
velocity/speed (of the ions) / strength of electric field; 
m/s scores the first two marking points. [3 max]

(iii) \( A_i = \frac{[(0.56 \times 84) + (9.90 \times 86) + (7.00 \times 87) + (82.54 \times 88)]}{100} \) ; 
= 87.71 ; [2]

Award [1 max] if answer not given to two decimal places. 
Award [2] for correct final answer. 
Apply –1(U) if answer quoted in g or g mol⁻¹.

Q# 12/ IB Chem/2008/w/TZ0/Paper 2 Section A/Standard Level/

2. (a) (atoms of the) same element / atoms with same number of protons/atomic number/Z; 
Do not award mark if no mention of atom or element. [2]

(b) (i) \( (82 \times 0.1580) + (84 \times 0.6540) + (86 \times 0.1880) \) / other working; 
84.06; [2]

Consider ECF for final answer if correct method is used but transcription or 
arithmetic error is present in the first stage. 
Award [2] for correct final answer with or without working.

(ii) 36 protons and 36 electrons; 
48 neutrons; [2]

Q# 13/ IB Chem/2008/s/TZ1/Paper 2 Section A/Standard Level/

2. (a) \( \frac{69.8}{100} + \frac{1 \times 0.6}{100} \); 
69.8; [2]

(b) (i) Potassium ion 2.8.8; 
(ii) Sulfide ion 2.8.8; 
Allow electron configuration in terms of spdf. [2]

(c) (continuous spectrum) has all colours/wavelengths/frequencies; 
(line spectrum) has only lines of specific colours/wavelengths/frequencies/has some 
 colours missing; [2]

Q# 14/ IB Chem/2007/w/TZ0/Paper 2 Section A/Standard Level/
2. (a) ratio of average mass of an atom to \( \frac{1}{12} \) the mass of C-12 isotope / average mass of an atom on a scale where one atom of C-12 has a mass of 12 / sum of the weighted average mass of isotopes of an element compared to C-12 / OWTTE; Award no mark if ‘element’ is used in place of ‘atom’ [1]

(b) \(^{63}\text{Cu}\) (more abundant) since \(A_i\) \((\text{Cu})\) is closer in mass to 63; Explanation needed for mark [1]

(c) different physical properties/melting points/boiling points/density/reaction rate/mass; due to different masses/more neutrons/nucleons; same/similar chemical properties/reactivity; due to same arrangement of valence electrons; [4]

Q# 15/ IB Chem/2007/w/TZ0/Paper 2 Section A/Standard Level/

2. (a) ratio of average mass of an atom to \( \frac{1}{12} \) the mass of C-12 isotope / average mass of an atom on a scale where one atom of C-12 has a mass of 12 / sum of the weighted average mass of isotopes of an element compared to C-12 / OWTTE; Award no mark if ‘element’ is used in place of ‘atom’ [1]

(b) \(^{63}\text{Cu}\) (more abundant) since \(A_i\) \((\text{Cu})\) is closer in mass to 63; Explanation needed for mark [1]

(c) different physical properties/melting points/boiling points/density/reaction rate/mass; due to different masses/more neutrons/nucleons; same/similar chemical properties/reactivity; due to same arrangement of valence electrons; [4]

Q# 16/ IB Chem/2007/s/tz1/Paper 2 Section B/Standard Level/

(f) \(A_i\) \((\text{Cl})\) = \(35.45 = \frac{35x + 37(100 - x)}{100}\); 

\(^{35}\text{Cl} = 77.5 \% \text{ and } ^{37}\text{Cl} = 22.5 \%\); [2]

Q# 17/ IB Chem/2006wQ3

(b) \(\text{Si} \ 2.8.4 / 2.8.4, \ P^5 \ 2.8.8 / 2.8.8\); [2]

(c) 16 protons and 17 neutrons and 18 electrons; [1]

Q# 18/ IB Chem/2006/s/TZ1/Paper 2 Section A/Standard Level/
2. (a) (i) number of protons in the nucleus/atom; 
   *Do not accept protons and electrons.*

(ii) number of protons and neutrons in the nucleus/atom; [1]

(b) \( A_{I} (\text{TI}) = 203 \times 0.2952 + 205 \times 0.7048 / 204.41; \)
\( A_{I} (\text{Br}) = 79 \times 0.5069 + 81 \times 0.4931 / 79.99; \)
\( M_{I} (\text{TI}Br_{I}) = 204.41 + 3 \times 79.99 = 444.38 / 444.37; \) [3]

*Correct answer scores [3].*

*Ignore units of g or g mol\(^{-1}\).*

*Apply ECF to \( M_{I} \) from \( A_{I} \) values.*

(c) Mg\(^{2+}\); [1]

(d) Al\(^{3+}\), O\(^{2-}\), Ne, Na\(^{+}\), F\(^{-}\), N\(^{3-}\); [2]

*Do not accept F\(^{-}\).*

Q# 19/ IB Chem/2005/w/TZ0/Paper 2 Section A/Standard Level/

3. (a) | an atom of $^{79}$Br | an ion of $^{81}$Br$^-^-$ |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>protons</td>
<td>35</td>
</tr>
<tr>
<td>neutrons</td>
<td>44</td>
</tr>
<tr>
<td>electrons</td>
<td>35</td>
</tr>
</tbody>
</table>

(b) $^{79}$Br because $A_i$ is closer to $79 / OWTTE$. [1]

(c) (i) 2.8.8.2 / 2.8.8.2; [1]

(ii) CaBr$_2$; [1]

Q# 20/ IB Chem/2004/s/TZ1/Paper 2 Section A/Standard Level/

2. (a) atoms of the same element / same number of protons / same atomic number; having different numbers of neutrons / different (mass number); Award only [1] max if reference made to elements but not atoms.

(b) relative atomic mass = $\frac{36 \times 0.337 + 38 \times 0.0630 + 40 \times 0.996}{100}$

= 39.98 / 39.99 / 40.0; [2]

(c) 23 electrons;
26 protons;
30 neutrons;

Q# 21/ IB Chem/2003/w/TZ0/Paper 2 Section A/Standard Level/

3. (a) mass / density / for gases: rate of effusion or diffusion / melting point / boiling point [1]

Do not accept mass number.

(b) if $^{35}$Cl = x, then $(x \times 35.00) + (1-x) \times 37.00 = 35.45$;
Award [1] for set up.

therefore, $x = 0.775$
$^{35}$Cl = 77.5% and $^{37}$Cl = 22.5%; [2]
(need both for mark);

Q# 22/ IB Chem/2002/w/TZ0/Paper 2 Section A/Standard Level/

2. | Protons | Neutrons | Electrons |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{27}$Al</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>$^{24}$Mg$^{2+}$</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>$^{16}$O$^{2-}$</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

[1] [1] [1] [3]

All three correct for a sub-atomic particle [1].
Q# 23/ IB Chem/2001/s/tz1/Paper 2 Section B/Standard Level/

5. (a) *(First [3] marks could be scored from a labelled diagram)*
   Line spectrum [1]
   *(Lines) converge [1]*
   At high energy / high frequency / shorter wavelength / blue end of spectrum [1]
   Electron transition between energy levels [1] *(either direction)*
   Each transition / line is related to energy difference $\Delta E = \frac{hc}{\lambda}$ / $E = hv$ [1]

[5 max]

Q# 24/ IB Chem/2001/s/TZ1/Paper 2 Section A/Standard Level/

3. (a) *(Atomic number)*
   Number of protons in an atom / nucleus [1]
   *(Mass number)*
   Number of protons and neutrons in an atom / nucleus [1]

   \[
   \begin{array}{|c|c|c|c|}
   \hline
   \text{Species} & \text{Protons} & \text{Neutrons} & \text{Electrons} \\
   \hline
   ^{14}_{6}C & 6 & 8 & 6 \\
   \hline
   ^{19}_{8}F^{-} & 9 & 10 & 10 \\
   \hline
   ^{20}_{26}Ca^{2+} & 20 & 20 & 18 \\
   \hline
   \end{array}
   \]

   [1] [1] [1] [2 max]

Q# 25/ IB Chem/2000/w/tz0/Paper 2 Section B/Standard Level/

5. (a) mass number = number of (protons + neutrons) [1]
   atomic number = number of protons (= Z) [1]
   number of electrons = number of protons (= Z) [1]
   number of neutrons = A – Z [1]

   (b) $C : 2, 4$ *(accept 2,4)* [1]
   $^{12}_{6}C^{-} : 6$ protons, 6 neutrons [1]
   10 electrons [1]
   Protons and neutrons in the nucleus and electrons in shells / orbits [1]

   (c) If fraction of $^{35}_{17}Cl = x$, then $35.0x + 37.0(1 – x) = 35.5$ / other sensible working [1]

   75 % $^{35}_{17}Cl$. [1]

   Similar: number of electrons / number of electron shells / number of valence $e^{-}$ / chemical properties; [1]

   *(Accept any two.)*

   Different: physical property (which depends on mass). *(Accept different boiling points OR different rates of diffusion OR different melting points OR…)* [1]
Q# 26/ IB Chem/1999/s/tz1/Paper 2 Section B/Standard Level/

4. (a) mass number: number of protons and neutrons (in the nucleus) [1 mark]
atomic number: number of protons/number of electrons in the atom [1 mark]

(b) $^{23}$Na
   11p, 11e$^-$, 12n
   2, 8, 1 [1 mark]

$^{39}$K$^-$
   19p, 18e$^-$, 20n
   2, 8, 8 [1 mark]

$^{35}$Cl$^-$
   17p, 18e$^-$, 18n
   2, 8, 8 [1 mark]

Allow s, p notation if correct [1 mark]

(d) $^{35}$Cl is the more abundant [1 mark]
35.5 is nearer to 35 (than to 37)/35.5 means 75% $^{35}$Cl [1 mark]

(e) (i) The lines become closer together/converge [1 mark]
then converge/form a (thick) band/cease [1 mark]

(ii) electrons/electronic changes [1 mark]
change energy (levels) [1 mark]