IB HL Topics 2, EQ P2 Paper 2 Section A and Section B 205marks 16w to 99s

After 2016 there was a change in the SL syllabus that meant some HL material is now in the SL section (to try to give IB SL Chemistry parity with the AS Chemistry)

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

4. Magnesium is a group 2 metal which exists as a number of isotopes and forms many compounds.

(a) State the nuclear symbol notation, ${}^{A}_{Z}X$, for magnesium-26. [1]

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

	% abundance
Mg-24	78.60
Mg-25	10.11
Mg-26	11.29

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

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(c) Magnesium ions produce no emission or absorption lines in the visible region of the electromagnetic spectrum. Suggest why most magnesium compounds tested in a school laboratory show traces of yellow in the flame. [1]

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(d) (i) Explain the convergence of lines in a hydrogen emission spectrum. [1]

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Q# 2/ IB Chem/2016/s/TZ1/Paper 2 Section A/Higher Level/Q4

(iv) Vanadium is comprised almost entirely of ^{51}V. State the number of neutrons an atom of ^{51}V has in its nucleus. [1]

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Q# 3/ IB CHEM/2015/s/TZ1/Paper 2 Section B/Higher Level/Q7

Table 5 refers to the periodic table

(g) The two most abundant isotopes of bromine have the mass numbers 79 and 81. Calculate the relative abundance of ^{79}Br using table 5 of the data booklet, assuming the abundance of the other isotopes is negligible. [2]

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Q# 4/ IB CHEM/2014/w/TZ0/Paper 2 Section B/Higher Level/

8. A sample of magnesium contains three isotopes: magnesium-24, magnesium-25 and magnesium-26, with abundances of 77.44%, 10.00% and 12.56% respectively.

(a) (i) Calculate the relative atomic mass of this sample of magnesium correct to **two** decimal places. *[2]*

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(ii) Predict the relative atomic radii of the three magnesium isotopes, giving your reasons. *[2]*

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Q# 5/ IB Chem/2014/s/TZ2/Paper 2 Section A/Higher Level/

2. There are only two isotopes, $^{63}_{29}Cu$ and $^{65}_{29}Cu$, in naturally occurring copper.

(a) The relative atomic mass of copper is 63.55. Calculate the percentage of $^{63}_{29}Cu$ in the naturally occurring element. *[2]*

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Q# 6/ IB Chem/2014/s/TZ1/Paper 2 Section A/Higher Level/

3. Magnesium has three stable isotopes, ^{24}Mg, ^{25}Mg and ^{26}Mg. The relative abundance of each isotope is 78.99%, 10.00% and 11.01%, respectively, and can be determined using a mass spectrometer.

(b) Calculate, showing your working, the relative atomic mass, A_r, of magnesium, giving your answer to **two** decimal places. *[2]*

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

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

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(ii) Calculate the percentage abundance of **each** isotope, given that the relative atomic mass of B is 10.81. *[2]*

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(b)

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

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(c) Phosphorus forms two chlorides, PCl_3 and PCl_5.

(i) Apply the Aufbau principle to state the **full** electron configuration for an atom of phosphorus. *[1]*

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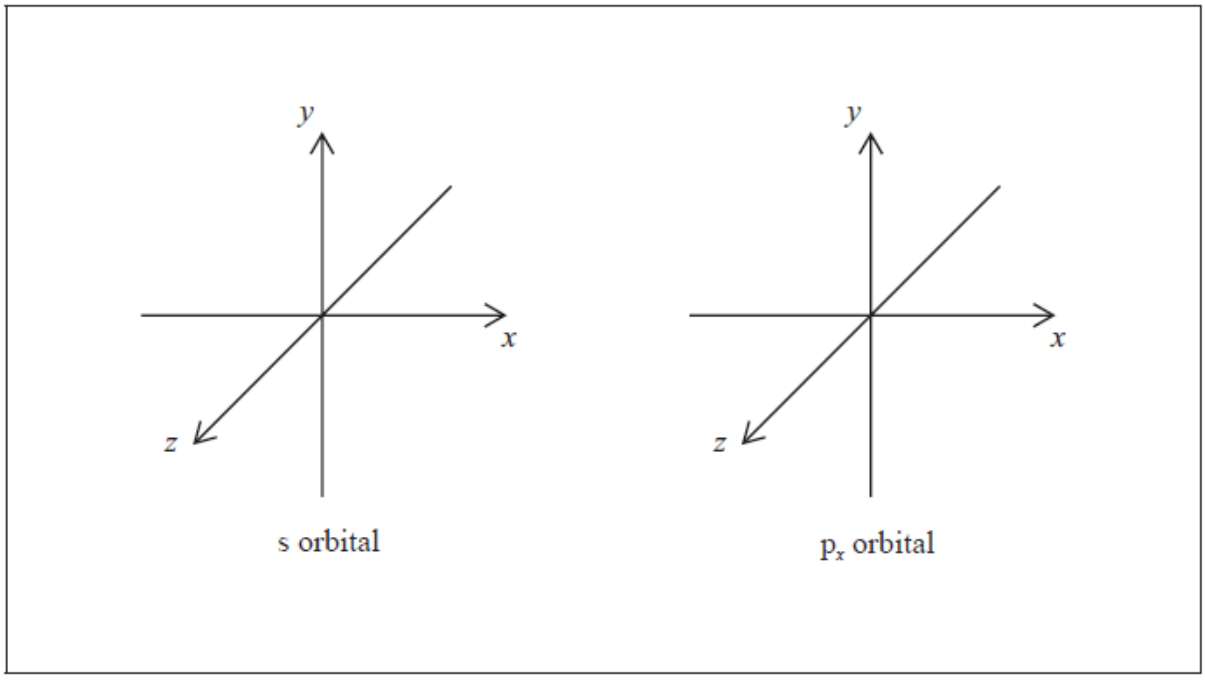
Q# 8/ IB Chem/2012/w/TZ0/Paper 2 Section A/Higher Level/Q2(a)

(ii) Lithium exists as two isotopes with mass numbers of 6 and 7. Deduce the number of protons, electrons and neutrons for each isotope. *[2]*

Mass number (*A*)	Number of protons	Number of electrons	Number of neutrons
6			
7			

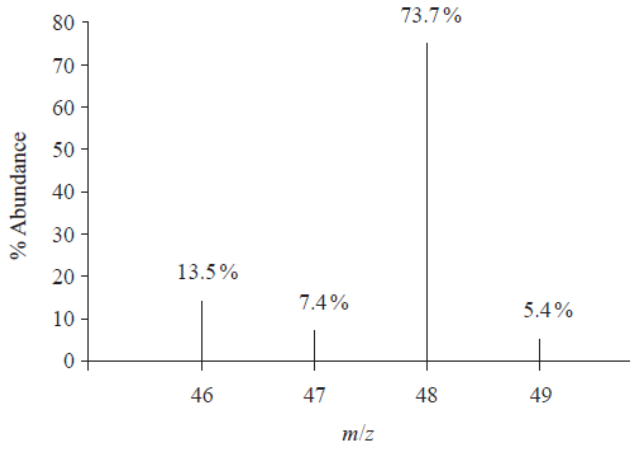
(iii) The electron configuration of boron is $1s^2 2s^2 2p^1$. Draw the shape of an s orbital and a p_x orbital on the axes below. *[1]*



Q# 9/ IB Chem/2012/s/TZ1/Paper 2 Section B/Higher Level/

8. The element titanium is present in meteorites.

(a) A meteorite was analysed using mass spectrometry (MS). The mass spectrum below shows the relative abundances of the different titanium isotopes.



(ii) Define the term *relative atomic mass* (A_r). *[1]*

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(iii) Calculate the relative atomic mass of this sample of titanium, giving your answer to one decimal place. *[2]*

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(c) Successive ionization energy data provides evidence for the existence of energy levels in atoms. Other evidence is provided by the hydrogen emission spectrum.

(i) Describe the appearance of the visible emission spectrum of hydrogen. *[2]*

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(ii) Explain how this spectrum is related to the electron energy levels in a hydrogen atom. *[3]*

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Q# 10/ IB Chem/2011/w/TZ0/Paper 2 Section A/Higher 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. *[2]*

Symbol	$^{59}Co^{3+}$	^{60}Co	
Number of protons	27		53
Number of neutrons		33	72
Number of electrons		27	53

(c) State the **full** electron configuration of $^{59}Co^{3+}$. *[1]*

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Q# 11/ IB Chem/2011/s/TZ1/Paper 2 Section A/Higher Level/

3. (a) Explain why the relative atomic mass of cobalt is greater than the relative atomic mass of nickel, even though the atomic number of nickel is greater than the atomic number of cobalt. *[1]*

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(b) Deduce the numbers of protons and electrons in the ion Co^{2+}. *[1]*

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(c) Deduce the electron configuration for the ion Co^{2+}. *[1]*

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Q# 12/ IB Chem/2010/w/TZ0/Paper 2 Section A/Higher Level/Q3

(b) A sample of iron has the following isotopic composition by mass.

Isotope	^{54}Fe	^{56}Fe	^{57}Fe
Relative abundance / %	5.95	91.88	2.17

Calculate the relative atomic mass of iron based on this data, giving your answer to **two decimal places.** *[2]*

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Q# 13/ IB Chem/2010/w/TZ0/Paper 2 Section A/Higher Level/Q3

(d) State the full electronic configurations of a Cu atom and a Cu^+ ion. *[2]*

Cu: . . . . . .

Cu^+: . . . . . .

Q# 14/ IB Chem/2010/s/TZ1/Paper 2 Section B/Higher Level/

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

(c) The relative atomic mass of naturally occurring copper is 63.55. Calculate the abundances of ^{63}Cu and ^{65}Cu in naturally occurring copper. *[2]*

Q# 15/ IB Chem/2009/w/TZ0/Paper 2 Section A/Higher Level/

3. (a) Describe the emission spectrum of hydrogen. Outline how this spectrum is related to the energy levels in the hydrogen atom. *[3]*

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Q# 16/ IB Chem/2009/s/TZ1/Paper 2 Section B/Higher Level/Q8a

(iii) Strontium exists as four naturally-occurring isotopes. Calculate the relative atomic mass of strontium to two decimal places from the following data. *[2]*

Isotope	Percentage abundance
Sr-84	0.56
Sr-86	9.90
Sr-87	7.00
Sr-88	82.54

Q# 17/ IB Chem/2008/w/TZ0/Paper 2 Section A/Higher Level/

2. (a) Define the term *isotopes*. *[2]*

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(b) A sample of krypton contains these isotopes.

Isotope	Percentage abundance
^{82}Kr	15.80
^{84}Kr	65.40
^{86}Kr	18.80

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

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

Protons . . . . . .

Neutrons . . . . . .

Electrons . . . . . .

(c) Krypton and xenon are in the same group of the periodic table.

(i) Complete the following to show the electron configuration of krypton. *[1]*

$1s^2 2s^2 2p^6$ .....

(ii) State the number of electrons in d orbitals in an atom of xenon in its ground state. *[1]*

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Q# 18/ IB Chem/2008/s/TZ1/Paper 2 Section A/Higher Level/Q2

(b) Naturally occurring boron consists of the two isotopes, ^{10}B and ^{11}B. The relative atomic mass of boron is 10.81. Determine the percentage abundance of these isotopes. *[2]*

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Q# 19/ IB Chem/2007/w/TZ0/Paper 2 Section A/Higher Level/

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

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

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

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(b) (i) Explain why successive ionization energies of an element increase. *[1]*

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(ii) Explain how successive ionization energies account for the existence of three main energy levels in the sodium atom. *[3]*

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(c) State the formula of a stable ion formed from elemental vanadium. Identify which electrons are lost when the ion forms. *[2]*

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Q# 20/ IB Chem/2007/s/TZ0/Paper 2 Section B/Higher Level/Q8

(b) (i) State the meaning of the term *isotopes* of an element. *[1]*

(ii) Calculate the percentage abundance of the two isotopes of rubidium ^{85}Rb and ^{87}Rb. *[2]*

(iii) State **two** physical properties that would differ for each of the rubidium isotopes. *[1]*

(iv) Determine the full electron configuration of an atom of Si, an Fe^{3+} ion and a P^{3-} ion. *[3]*

Q# 21/ IB Chem/2006/w/TZ0/Paper 2 Section A/Higher Level/

5. Some vaporized magnesium is introduced into a mass spectrometer. One of the ions that reaches the detector is $^{25}Mg^{+}$.

(a) Identify the number of protons, neutrons and electrons in the $^{25}Mg^{+}$ ion. *[1]*

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Q# 22/ IB Chem/2006/s/TZ0/Paper 2 Section A/Higher Level/

2. (a) Use the data below to calculate the relative molecular mass of thallium bromide, $TlBr_3$, to two decimal places. *[3]*

Isotope	Percentage Abundance
^{203}Tl	29.52
^{205}Tl	70.48
^{79}Br	50.69
^{81}Br	49.31

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(b) The value of the relative molecular mass of hydrogen bromide is 80.91, correct to two decimal places. Explain why no molecule in a sample of hydrogen bromide has this M_r value. *[2]*

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(c) State the full electron configuration for a bromide ion. *[1]*

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(d) Write the symbol for the ion with a 2+ charge which has the electron configuration of $1s^2 2s^2 2p^6$. *[1]*

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(e) Write the symbols for **three** other species, which also have the electron configuration of $1s^2 2s^2 2p^6$. *[2]*

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Q# 23/ IB Chem/2005/w/TZ0/Paper 2 Section A/Higher Level/Q2

(b) The sample of germanium is found to have the following composition:

Isotope	^{70}Ge	^{72}Ge	^{74}Ge	^{76}Ge
Relative abundance / %	22.60	25.45	36.73	15.22

(i) Define the term *relative atomic mass*. *[2]*

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(ii) Calculate the relative atomic mass of this sample of germanium, giving your answer to two decimal places. *[2]*

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(c) Use the Aufbau principle to write the electron configuration of an atom of germanium. *[1]*

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Q# 24/ IB Chem/2004/s/TZ0/Paper 2 Section B/Higher Level/

8. (a) (i) State the full electron configuration for argon. *[1]*

(ii) Give the formulas of **two** oppositely charged ions which have the same electron configuration as argon. *[2]*

Q# 25/ IB Chem/2004/s/TZ0/Paper 2 Section A/Higher Level/

4. (a) Define the term *isotope*. *[2]*

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(b) A sample of gallium exists as two isotopes, ^{69}Ga, relative abundance 61.2 %, and ^{71}Ga, relative abundance 38.8 %. Calculate the relative atomic mass of gallium. *[1]*

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Q# 26/ IB Chem/2004/s/TZ0/Paper 2 Section A/Higher Level/

5. (a) Evidence for the existence of energy levels in atoms is provided by line spectra. State how a line spectrum differs from a continuous spectrum. *[1]*

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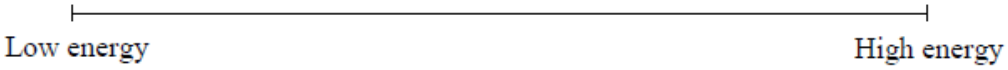
(b) On the diagram below draw **four** lines in the visible line spectrum of hydrogen. *[1]*



(c) Explain how the formation of lines indicates the presence of energy levels. *[1]*

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Q# 27/ IB Chem/2003/w/TZ0/Paper 2 Section A/Higher Level/

3. (a) State a physical property that is different for isotopes of an element. *[1]*

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(b) Chlorine exists as two isotopes, ^{35}Cl and ^{37}Cl. The relative atomic mass of chlorine is 35.45. Calculate the percentage abundance of each isotope. *[2]*

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(c) State the complete electronic configuration of bromine, Br and the iron(III) ion, Fe^{3+}. *[2]*

Br: . . . . . .

Fe^{3+}: . . . . . .

Q# 28/ IB Chem/2003/s/TZ0/Paper 2 Section A/Higher Level/

(b) Tritium, $^{3}_{1}T$, is an isotope of hydrogen.

(i) State the number and type of sub-atomic particles in a tritium atom and the location of each type. *[2]*

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(ii) Write balanced equations to represent the formation of the following compounds, starting with T_2 or T_2O. *[4]*

NT_3: . . . . . .

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NaOT: . . . . . .

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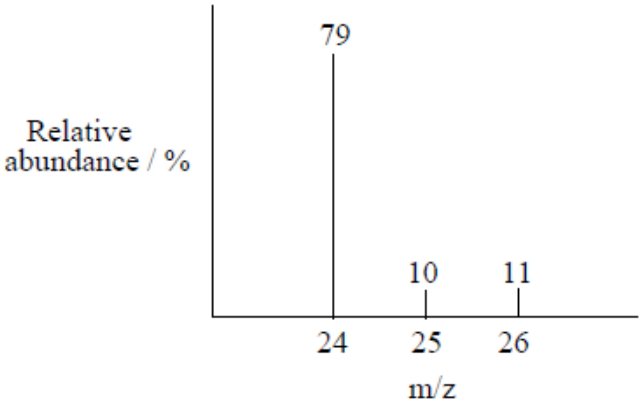
Q# 29/ IB Chem/2002/w/TZ0/Paper 2 Section A/Higher Level/Q2

(c) The mass spectrum for an element is given below.



(i) Explain why there is more than one peak. *[1]*

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(ii) Calculate, to two decimal places, the relative atomic mass of the element. *[2]*

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Q# 30/ IB Chem/2002/s/TZ0/Paper 2 Section A/Higher Level/Q2

(c) The relative abundances of the three isotopes of magnesium are as follows:

$^{24}Mg = 78.6\,\%$, $^{25}Mg = 10.1\,\%$, $^{26}Mg = 11.3\,\%$.

Calculate the relative atomic mass of magnesium using these values, giving your answer to three decimal places. *[2]*

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(d) Write the electronic configuration of magnesium using the spdf notation. *[1]*

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Q# 31/ IB Chem/2001/w/TZ0/Paper 2 Section B/Higher Level/

5. (a) The isotopes of sulfur occur naturally in the following percentages:

^{32}S: 95.0 %, ^{33}S: 0.76 %, ^{34}S: 4.20 %, and ^{36}S: 0.020 %

(i) Calculate the relative atomic mass of sulfur to three significant figures. *[2]*

(ii) Determine the number of neutrons in the atom of the **least** abundant sulfur isotope. *[1]*

(b)

(ii) State the electronic configurations of aluminium, boron and magnesium. Explain how the first ionisation energy of aluminium compares with the first ionisation energies of boron and magnesium. *[5]*

(c) When hydrogen gas is placed in an electric discharge tube, an emission spectrum is obtained. Sketch the spectrum, labelling its high energy end. Explain why such a spectrum is obtained. *[3]*

Q# 32/ IB Chem/2001/s/TZ0/Paper 2 Section A/Higher Level/

1. (a) Using the Periodic Table (Table 5) in the Data Booklet, give the symbol(s) of:

(i) an element with a ground state electronic configuration of [Xe] $6s^2 4f^{14} 5d^{10} 6p^1$. *[1]*

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(ii) an ion with a double positive charge (2+) with an electronic configuration of [Ar] $3d^5$. *[1]*

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(iii) **two** elements with a ground state configuration of ns^2np^3. *[1]*

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(b) Describe the emission spectrum of hydrogen. Explain how this spectrum is related to the energy levels in hydrogen. *[3]*

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(c) Give **two** reasons why the lithium ion, Li^+, has a smaller radius than the lithium atom. *[2]*

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Q# 33/ IB Chem/1999/s/TZ0/Paper 2 Section B/Higher Level/

6. Use the modern theory of the atom to answer each of the following.

(a) List the *d*, *f*, *p* and *s* orbitals in order of **increasing** relative energy. *[2]*

(b) Give the **number** of each type of orbital, *d*, *f*, *p* and *s* at each energy level. *[2]*

(c) Describe the changes which occur when hydrogen produces a line spectrum. *[2]*

(d) Explain why the electron configuration of the nitrogen atom is written as N: $1s^2 2s^2 2p^1 2p^1 2p^1$ rather than N: $1s^2 2s^2 2p^2 2p^1 2p^0$.
Write the electron configuration of titanium. *[3]*

Mark Scheme IB HL Topics 2, EQ P2 Paper 2 Section A and Section B 205marks 16w to 99s

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

Question			Answers	Notes	Total
4.	a		$^{26}_{12}Mg$ ✔		1
4.	b		«A_r =» $\frac{24 \times 78.60 + 25 \times 10.11 + 26 \times 11.29}{100}$ ✔ «= 24.3269 =» 24.33 ✔	*Award **[2]** for correct final answer.* *Do **not** accept data booklet value (24.31).*	2
4.	c		contamination with sodium/other «compounds» ✔		1
4.	d	i	energy levels are closer together at high energy / high frequency / short wavelength ✔		1

Q# 2/ IB Chem/2016/s/TZ1/Paper 2 Section A/Higher Level/

4.	e	iv	28 ✔		1

Q# 3/ IB CHEM/2015/s/TZ1/Paper 2 Section B/Higher Level/Q7

(g) $79.91 = 79x + 81(1-x)$;
Award M1 for any suitable calculation.
(abundance ^{79}Br =) 54.5 %; **[2]**
*Award **[2]** for correct final answer.*

Q# 4/ IB CHEM/2014/w/TZ0/Paper 2 Section B/Higher Level/

8. (a) (i) $\left(\frac{(77.44\times24)+(10.00\times25)+(12.56\times26)}{100}\right)$;
24.35; *[2]*
Award [2] for correct final answer.
Two decimal places are required for M2.
Do not award any marks for 24.31 without showing method (as the value can be copied from the Data Booklet).

(ii) same atomic radii / 160 pm;
isotopes only differ by number of neutrons/size of nucleus / radius determined by electron shells and number of protons / *OWTTE*; *[2]*
Accept neutrons do not affect distance of electrons / OWTTE.

(b) (i) decreasing repulsion between electrons / radius decreases as electrons are removed; *[1]*
Accept increasing positive charge on ion attracts electrons more strongly.

(ii) 10^{th} electron is in second energy level/shell while 11^{th} electron is in first energy level/shell / 10^{th} is removing electron from electronic arrangement 2,1 while 11^{th} ionization energy is removing electron from electronic arrangement 2;
11^{th} electron removed is much closer to the nucleus / 11^{th} electron removed from a (much) lower energy level/shell; [2]
Accept opposite statement for 10^{th} electron.

Q# 5/ IB Chem/2014/s/TZ2/Paper 2 Section A/Higher Level/

2. (a) $63x+65(100-x)=63.55\times100$;
$(x=)72.50(\%)$; [2]
Award [2] for correct final answer.

Q# 6/ IB Chem/2014/s/TZ1/Paper 2 Section A/Higher Level/Q3

(b) $(A_r=)0.7899\times24+0.1000\times25+0.1101\times26$;
24.32; [2]
Award [2] for correct final answer.
Award [1 max] for 24.31 with correct working.
Award [0] for 24.31 (Data Booklet value) if working is incorrect or no working is shown.
Final answer must be to 2 decimal places to score [2].

Q# 7/ IB Chem/2013/s/TZ1/Paper 2 Section B/Higher 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}B: 19% **and** ^{11}B: 81%; [2]

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

(c) (i) $1s^2 2s^2 2p^6 3s^2 3p^3$; [1]

Q# 8/ IB Chem/2012/w/TZ0/Paper 2 Section A/Higher Level/Q2

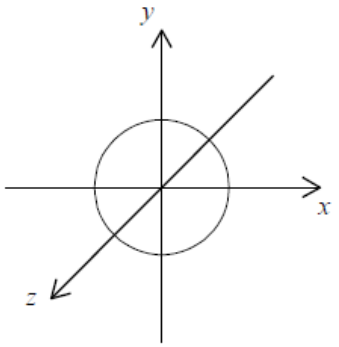
(ii)

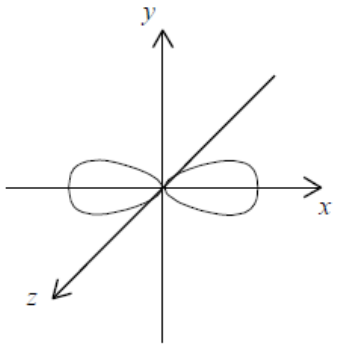
Mass number (A)	Number of protons	Number of electrons	Number of neutrons	
6	3	3	3	;
7	3	3	4	;

[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.

(iii) symmetrical shape of s orbital **and** dumbbell-shaped p orbital with electron density along *x*-axis; *[1]*





Q# 9/ IB Chem/2012/s/TZ1/Paper 2 Section B/Higher Level/Q8a

(ii) ratio of average/mean mass of an atom to the mass of C-12 isotope / average/mean mass of an atom on a scale where one atom of C-12 has a mass of 12 / sum of the weighted average/mean mass of isotopes of an element compared to C-12 / *OWTTE*; *[1]*
Award no mark if "element" is used instead of "atom".

(iii) $A_r = \frac{(46\times13.5)+(47\times7.4)+(48\times73.7)+(49\times5.4)}{100}$;
47.7; *[2]*
*Accept atomic mass units but award **[1 max]** if other units given.*
Answer must be given to one decimal place.

(c) (i) line spectrum;
(lines) converge at high energy/frequency/shorter wave length/blue end of spectrum; *[2]*
Both marks can be awarded if suitable diagram is given.

(ii) electron transition from higher to lower/second energy levels;
each transition causes emission of light of specific frequency/wavelength/energy;
each transition/line is related to energy difference / $\Delta E = \frac{hf \,/\, hv \,/\, hc}{\lambda}$;
energy levels in hydrogen atom are closer/converge at higher energy; *[3 max]*

Q# 10/ IB Chem/2011/w/TZ0/Paper 2 Section A/Higher Level/

2. (a)

Symbol	$^{59}Co^{3+}$	^{60}Co	^{125}I
Number of protons	27	27	53
Number of neutrons	32	33	72
Number of electrons	24	27	53

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

(b) Co-60 emits (penetrating) gamma radiation/rays / *OWTTE*; *[1]*
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.

(c) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$; *[1]*
Do not award mark for $[Ar]3d^6$.
Do not allow $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$.

Q# 11/ IB Chem/2011/s/TZ1/Paper 2 Section A/Higher Level/

3. (a) cobalt has a greater proportion of heavier isotopes / *OWTTE* / cobalt has greater number of neutrons; *[1]*

(b) 27 protons **and** 25 electrons; *[1]*

(c) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$ / [Ar] $3d^7$; *[1]*

Q# 12/ IB Chem/2010/w/TZ0/Paper 2 Section A/Higher Level/Q3

(b) $\frac{(54 \times 5.95) + (56 \times 91.88) + (57 \times 2.17)}{100}$;

55.90; *[2]*

Award [2] for correct final answer.
Answer must be to 2 d.p.

Q# 13/ IB Chem/2010/w/TZ0/Paper 2 Section A/Higher Level/Q3

(d) *Cu*:
$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$;

Cu^+:
$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$; *[2]*

Ignore relative order of 3d and 4s.
Penalize only once if noble gas core is given.

Q# 14/ IB Chem/2010/s/TZ1/Paper 2 Section B/Higher Level/

4. (a) average mass of isotopes of an element compared to (1/12 g of) ^{12}C / average mass of an atom relative to C–12 having a mass of exactly 12 / *OWTTE*; *[1]*

Allow element instead of atom.
Must refer to average mass and C–12.

(c) $63x + 65(1–x) = 63.55$;
(or some other mathematical expression).

$^{63}Cu = 72.5$ % **and** $^{65}Cu = 27.5$ %; *[2]*

*Allow ^{63}Cu =0. 725 **and** ^{65}Cu =0. 275.*
*Award **[2]** for correct final answer .*

Q# 15/ IB Chem/2009/w/TZ0/Paper 2 Section A/Higher Level/

.3. (a) series of lines/lines;
electron transfer/transition between higher energy level to lower energy level / electron transitions into first energy level causes UV series / transition into second energy level causes visible series / transition into third energy level causes infrared series;
convergence at higher frequency/energy/short wavelength; *[3]*

Allow any of the above points to be shown on a diagram.

Q# 16/ IB Chem/2009/s/TZ1/Paper 2 Section B/Higher Level/Q8a

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

$= 87.71$; *[2]*

*Award **[1 max]** if answer not given to two decimal places.*
Apply –1(U) if answer quoted in g or g mol^{-1}.

Q# 17/ IB Chem/2008/w/TZ0/Paper 2 Section A/Higher 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.

(but) different numbers of neutrons/mass number/A; ***[2]***

(b) (i) $(82\times0.1580)+(84\times0.6540)+(86\times0.1880)$ / 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]***

(c) (i) $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^{10} 4s^2 4p^6$; ***[1]***
Accept $3d^{10}$ and $4s^2$ in reverse order.

(ii) 20; ***[1]***

Q# 18/ IB Chem/2008/s/TZ1/Paper 2 Section A/Higher Level/Q2

(b) $10x+(1-x)11=10.81$;
19 %;
81 %; ***[2 max]***
*Award **[2]** for two correct final answers.*

Q# 19/ IB Chem/2007/w/TZ0/Paper 2 Section A/Higher Level/

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

(ii) ^{63}Cu (more abundant) since A_r (Cu) is closer in mass to 63; ***[1]***
Explanation needed for mark

(b) (i) same nuclear charge, fewer electrons (thus more energy required to remove successive electrons) / harder to remove an electron from an ion with increasing positive charge / nucleus has greater effect on smaller number of electrons / *OWTTE*; ***[1]***

(ii) <u>large</u> increases in IE when 2nd **and** 10th electron removed;
thus, 1st electron further from nucleus than 2nd electron;
and 9th electron further from nucleus than 10th electron;
large increases indicate changes in main energy levels / *OWTTE*;

OR

outermost/3p electron has low IE because it is far/furthest from the nucleus;
electron(s) in second shell/2p electrons are much closer (to nucleus) **and** need much more energy to remove / IE much higher/very high / there is a big jump in IE;
electron(s) in first/innermost shell/1s electrons are even closer (to nucleus) and need much more energy to remove (than those in second shell/2s or 2p electrons); ***[3 max]***

(c) V^{2+} / V^{3+};

loss of $4s^2$ electrons / loss of $4s^2$ and a d electron; **[2]**

Do not accept V^{5+}/VO_2^+/VO_3^- but ECF from V^{5+} if correct number of electrons from the right orbitals stated.

Q# 20/ IB Chem/2007/s/TZ0/Paper 2 Section B/Higher Level/Q8

(b) (i) atoms with the same number of protons/positive charges/atomic number but different number of neutrons/mass number; **[1]**

(ii) $A_r(\text{Rb}) = 85.47 = \frac{85x + 87(100 - x)}{100}$;

Accept other valid mathematical alternatives

$^{85}\text{Rb} = 76.5$ and $^{87}\text{Rb} = 23.5\,\%$; **[2]**

(iii) mass;
density;
boiling point;
melting point;
rate of diffusion in the gas phase;
enthalpy of vaporization;
enthalpy of fusion;
rate of reaction in the gas/liquid phase; **[1 max]**

Any two for one mark

(iv) Si: $1s^2 2s^2 2p^6 3s^2 3p^2$;

Fe^{3+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$;

P^{3-} : $1s^2 2s^2 2p^6 3s^2 3p^6$; **[3]**

*Allow **[1 max]** for 3 correct abbreviated structures using noble gas symbols.*

Q# 21/ IB Chem/2006/w/TZ0/Paper 2 Section A/Higher Level/

5. (a) 12 protons and 13 neutrons and 11 electrons; **[1]**

Q# 22/ IB Chem/2006/s/TZ0/Paper 2 Section A/Higher Level/

2. (a) $A_r(\text{Tl}) = 203 \times 0.2952 + 205 \times 0.7048 / A_r(\text{Tl}) = 204.41$;

$A_r(\text{Br}) = 79 \times 0.5069 + 81 \times 0.4931 / A_r(\text{Br}) = 79.99$;

$M_r(\text{TlBr}_3) = 204.41 + 3 \times 79.99 = 444.38 / 444.37$; **[3]**

*Correct answer scores **[3]**.*
Ignore units of g or g mol^{-1}.
Apply ECF to M_r from A_r values.

(b) M_r is an <u>average</u> value (because of the isotopes);
each HBr molecule has its own value depending on which isotopes (of H or Br) it contains/*OWTTE*; **[2]**

(c) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$; **[1]**

Do not accept noble gas shortcut. No subscripts.

(d) Mg^{2+}; **[1]**

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

*Award **[2]** for any three, **[1]** for any two.*

Q# 23/ IB Chem/2005/w/TZ0/Paper 2 Section A/Higher Level/Q2

(b) (i) average or (weighted) mean of masses of all isotopes of an element;
relative to (one atom of) ^{12}C; *[2]*
Both marks available from a suitable expression.

(ii) $A_r = (70 \times 0.2260) + (72 \times 0.2545) + (74 \times 0.3673) + (76 \times 0.1522)$;
$= 72.89$; *[2]*
No other final answer acceptable.
Award [2] for correct final answer.

(c) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^2$ / $[Ar] 4s^2 3d^{10} 4p^2$; *[1]*
Do not penalize for interchanging $4s^2$ *and* $3d^{10}$.

Q# 24/ IB Chem/2004/s/TZ0/Paper 2 Section B/Higher Level/

8. (a) (i) $1s^2 2s^2 2p^6 3s^2 3p^6$; *[1]*
Do not accept [Ne] $3s^2 3p^6$ or 2, 8, 8.

(ii) K^+/ Ca^{2+}/ Sc^{3+}/ Ti^{4+};
Cl^-/ S^{2-}/ P^{3-}; *[2]*
Accept other suitable pairs of ions.

Q# 25/ IB Chem/2004/s/TZ0/Paper 2 Section A/Higher Level/

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

(b) relative atomic mass $= \frac{(69 \times 61.2 + 71 \times 38.8)}{100} = 69.8$; *[1]*
-1 *(SF) possible (treat 69 and 71 as integers)*

Q# 26/ IB Chem/2004/s/TZ0/Paper 2 Section A/Higher Level/

5. (a) continuous spectrum has all colours / wavelengths / frequencies whereas line spectrum has only (lines of) sharp / discrete / specific colours / wavelengths / frequencies; *[1]*

(b) lines get closer together towards high energy; *[1]*

(c) line represents electron transitions between energy levels / *OWTTE*; *[1]*

Q# 27/ IB Chem/2003/w/TZ0/Paper 2 Section A/Higher 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 $(x \times 35.00) + (1 - x)\, 37.00 = 35.45$;
Award [1] for set up.

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

(c) Br: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^5$ / $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^5$;

For Br, accept only complete configuration (which is asked for).

Fe^{3+}: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$; **[2]**

Accept $[Ar]\ 3d^5$ *since [Ar] already listed above.*

Q# 28/ IB Chem/2003/s/TZ0/Paper 2 Section A/Higher Level/

(b) (i) 1p, 2n, 1e⁻ ; p, n in nucleus, e⁻ orbiting / outside ; **[2]**

[1] for number and type of particles and [1] for location.

(ii) $N_2 + 3T_2 \rightarrow 2NT_3$;

*Correct formulas **[1]**, balancing of correct equation **[1]**.*

$2Na + 2T_2O \rightarrow 2NaOT + T_2$; **[4]**

*Correct formulas **[1]**, balancing of correct equation **[1]**.*
*If H is used instead of T in any of the equations **[3 max]**.*
Accept any other suitable equation for both parts.

Q# 29/ IB Chem/2002/w/TZ0/Paper 2 Section A/Higher Level/Q2

(c) (i) (existence / mixture of) isotopes / atoms with different number of neutrons; **[1]**

(ii) $\frac{(79\times 24)+(10\times 25)+(11\times 26)}{100}$

relative atomic mass = 24.32 **[2]**

Do not accept 24.3 / 24.31.

Q# 30/ IB Chem/2002/s/TZ0/Paper 2 Section A/Higher Level/Q2

(c) $(24\times 0.786)+(25\times 0.101)+(26\times 0.113)$ ***[1]***

$= 24.327$ *(must be to 3 decimal places)* ***[1]*** **[2]**

(d) $1s^2 2s^2 2p^6 3s^2$ / [Ne] $3s^2$ **[1]**

Q# 31/ IB Chem/2001/w/TZ0/Paper 2 Section B/Higher Level/

5. (a) (i) Average $A_r = \frac{(32.00\times 95.00)+(33.00\times 0.76)+(34.00\times 4.20)+(36.00\times 0.020)}{100}$ **[1]**

$= 32.1$ **[1]**

(ii) Number of neutrons in $^{36}S = 36 - 16 = 20$ **[1]**

(ii) Boron: $1s^2 2s^2 2p^1$ / [He] $2s^2 2p^1$ *[1]*

Aluminium: $1s^2 2s^2 2p^6 3s^2 3p^1$ / [Ne] $3s^2 3p^1$ *[1]*

Al has an e^- in a higher / third energy level further away from the nucleus that is easier to remove. *[1]*

Magnesium: $1s^2 2s^2 2p^6 3s^2$ / [Ne] $3s^2$ *[1]*

$3p^1$ is easier to remove than $3s^2$ as it is higher in energy. *[1]*

(c) Spectrum showing discrete lines *[1]*
converging at higher energy *[1]*
transition of (excited) electrons from higher energy levels to lower one(s). *[1]*

(Only one series need be shown to score mark.)

Q# 32/ IB Chem/2001/s/TZ0/Paper 2 Section A/Higher Level/

1. (a) (i) Tl *[1]*

(ii) Mn^{2+} (accept Mn) *[1]*

(iii) Any two of N, P, As, Sb, Bi *[1]*

(b) Lines (may be shown on diagram) *[1]*
Convergence at high frequency / energy / short wavelength (may be shown on a diagram) *[1]*
Electron transfer between energy levels / each transition / line depends on energy differences / $\Delta E = h\upsilon$ *[1]* *[3 max]*

(c) remaining electrons in one shell / Li^+ has one less shell or converse *[1]*
effective nuclear charge (Li^+) greater than that of the atom *[1]* *[2 max]*

Q# 33/ IB Chem/1999/s/TZ0/Paper 2 Section B/Higher Level/

6. (a) *s, p, d, f* *[2 marks]*
1 error, for example *s, p, f, d* or *p, s, d, f* deduct ***1 mark***
p, s, f, d ***0 marks***

(b) $d = 5$, $f = 7$, $p = 3$, $s = 1$

4 correct *[2 marks]*
2 or 3 correct *[1 mark]*
1 correct *[0 marks]*

Any answer which suggests the above

(c) Any 2 from 3:
electrons move (to lower) energy levels/orbitals *[1 mark]*
emitting energy as they do so *[1 mark]*
excitation and/or promotion to higher energy level *[1 mark]*

(d) Fill **singly before doubling** *[1 mark]*
since two **electrons** in the same orbital will **repel**/Hund's rule/orbitals are degenerate *[1 mark]*
Ti $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$ or reversed or Ar $3d^2 4s^2$ *[1 mark]*
Note: Must be superscript: $1s^2$

6. The periodic table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H 1.01						Atomic number **Element** Relative atomic mass											2 He 4.00
2	3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.90
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.96	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
6	55 Cs 132.91	56 Ba 137.33	57 † La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	89 ‡ Ac (227)	104 Rf (267)	105 Db (268)	106 Sg (269)	107 Bh (270)	108 Hs (269)	109 Mt (278)	110 Ds (281)	111 Rg (281)	112 Cn (285)	113 Uut (286)	114 Uuq (289)	115 Uup (288)	116 Uuh (293)	117 Uus (294)	118 Uuo (294)

†	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97
‡	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

Patrick Brannac