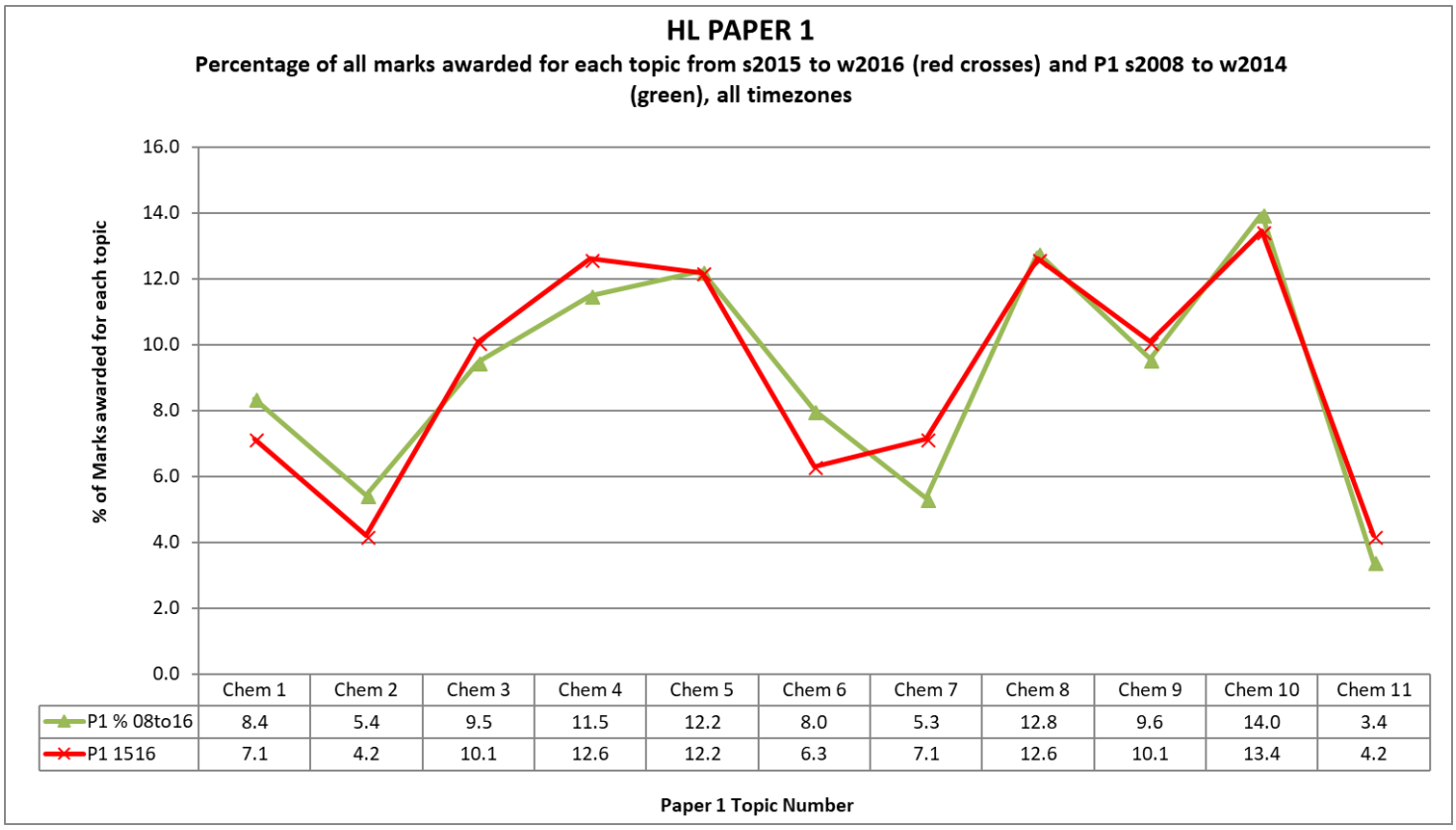
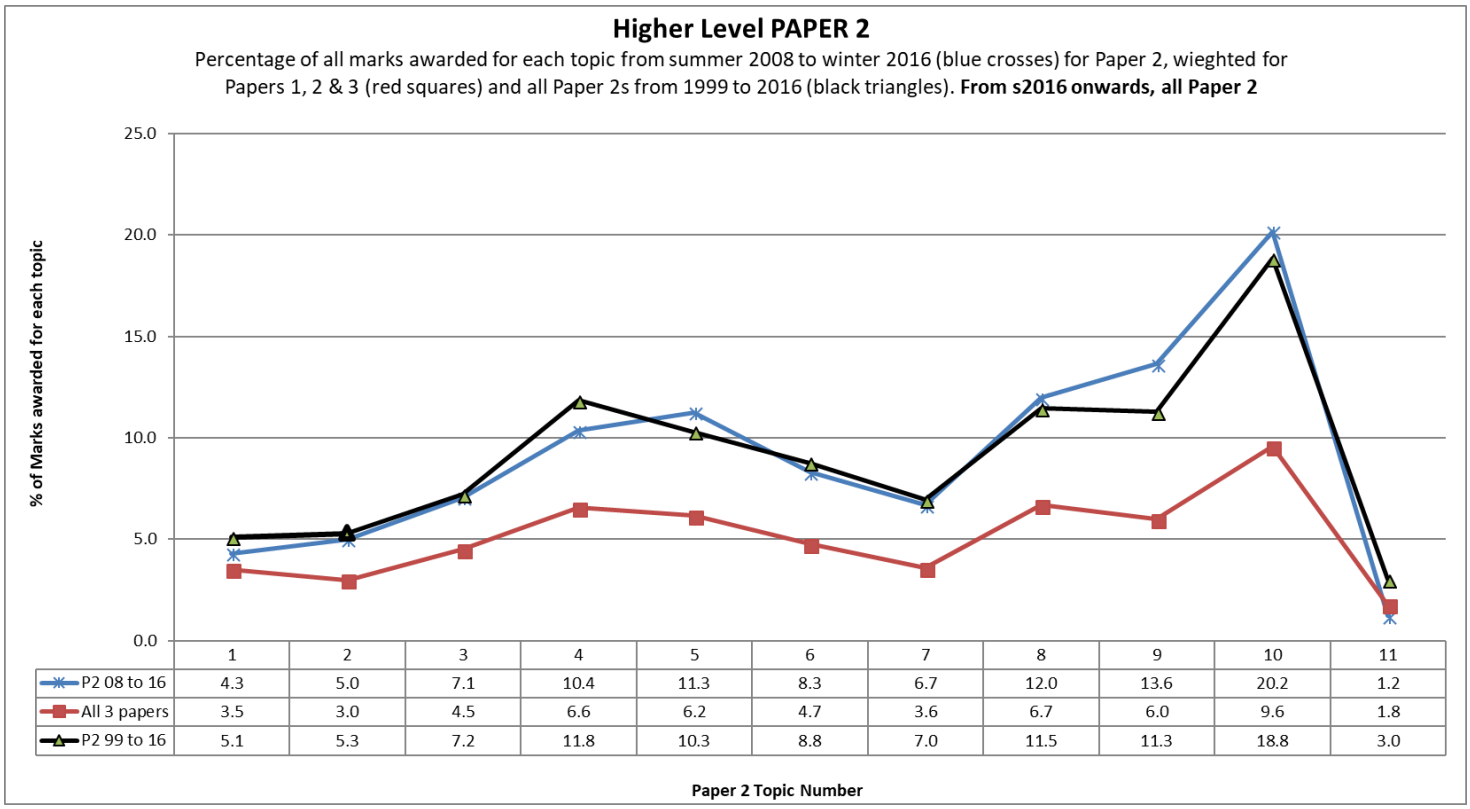
IB 2 HL P2 16w to 99s Paper Section A and Section B 205marks

All Higher Level topics have been combined with their respective Standard Level equivalent, so in HL topic 2 revision resources there will be topics 2 and 12.

From 2016 onwards, Section B which allowed candidates to chose 2 questions out of 4 in paper 2 was removed so that effectively the whole paper became like section A, and all questions were compulsory.



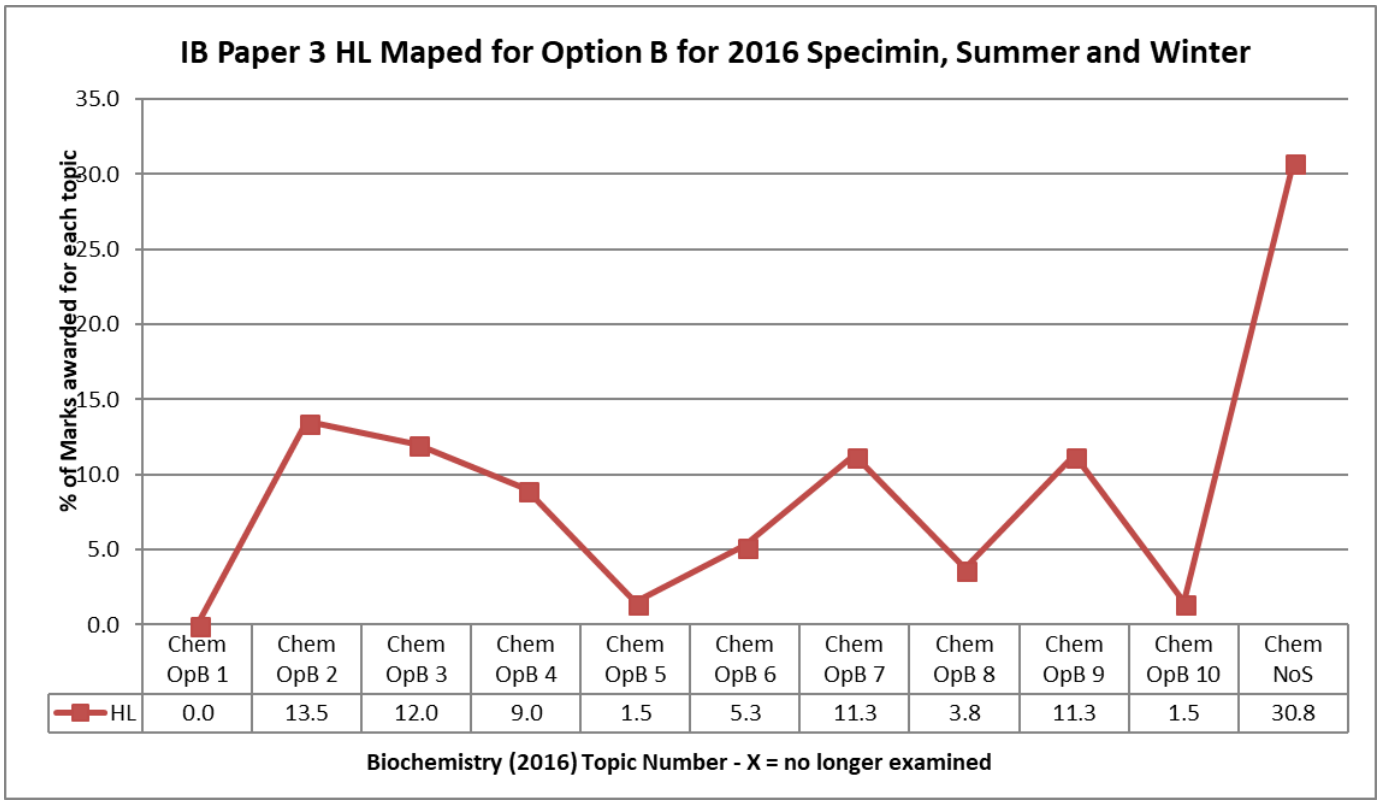
	Chem 1	Chem 2	Chem 3	Chem 4	Chem 5	Chem 6	Chem 7	Chem 8	Chem 9	Chem 10	Chem 11
P1 % 08to16	8.4	5.4	9.5	11.5	12.2	8.0	5.3	12.8	9.6	14.0	3.4
P1 1516	7.1	4.2	10.1	12.6	12.2	6.3	7.1	12.6	10.1	13.4	4.2

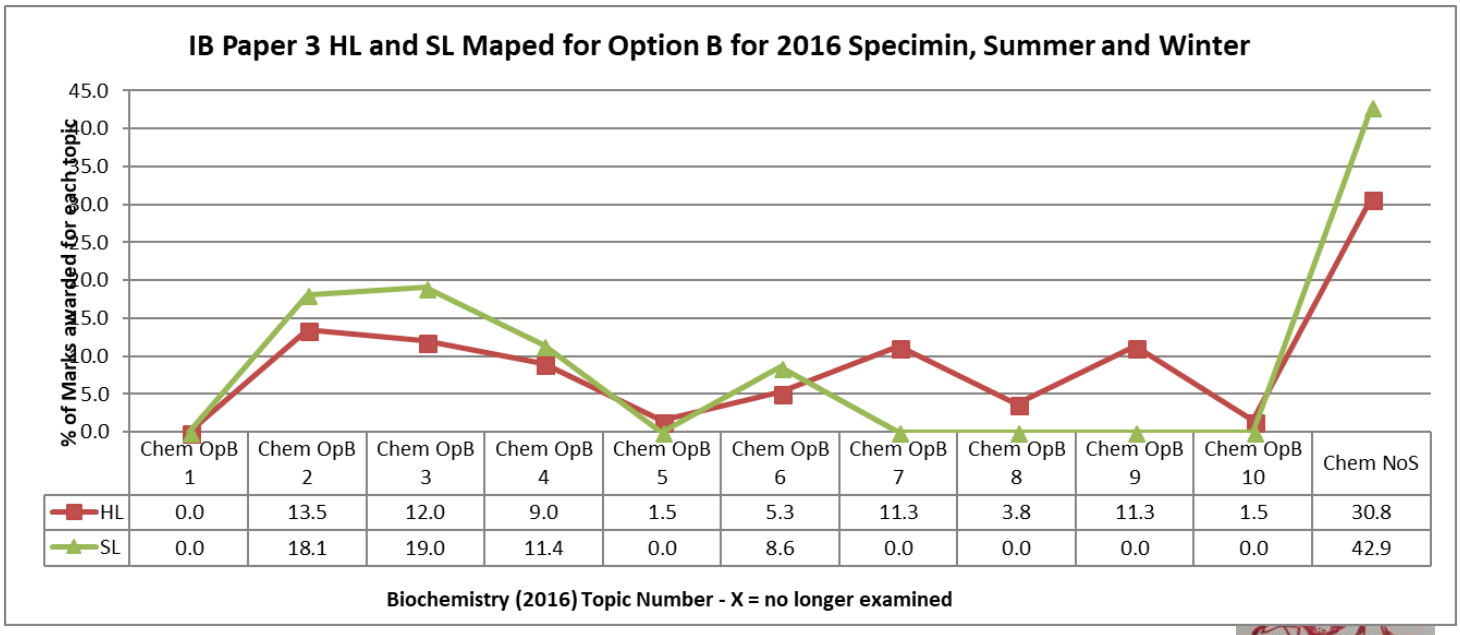


	1	2	3	4	5	6	7	8	9	10	11
P2 08 to 16	4.3	5.0	7.1	10.4	11.3	8.3	6.7	12.0	13.6	20.2	1.2
All 3 papers	3.5	3.0	4.5	6.6	6.2	4.7	3.6	6.7	6.0	9.6	1.8
P2 99 to 16	5.1	5.3	7.2	11.8	10.3	8.8	7.0	11.5	11.3	18.8	3.0

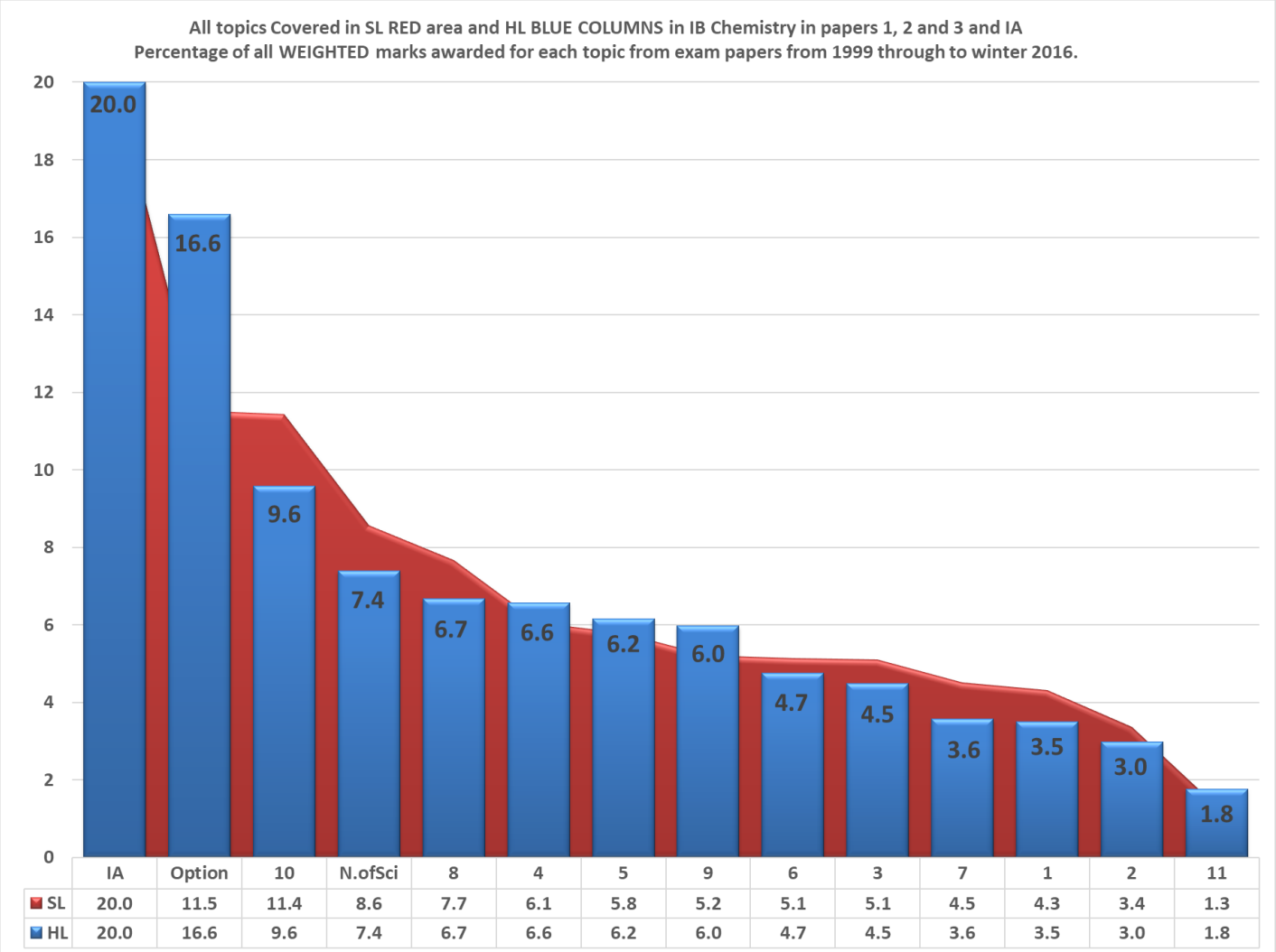
All topics ranked according to their impact on your final grade using exam papers from 1999 to 2016

Topic	Option	10	N.ofSci	8	4	5	9	6	1	3	7	2	11
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**14**
% of IB Grade	16.6	8.4	7.4	6.5	6.3	6.3	5.8	5.0	4.1	4.0	3.1	2.5	1.8
Paper 1		14.0		12.8	11.5	12.2	9.6	8.0	8.4	9.3	3.7	4.7	3.4
Paper 2 A		11.1		9.2	9.3	12.3	9.5	11.9	11.8	6.3	6.1	6.0	3.2
Paper 2 B		20.0		12.6	13.2	9.1	12.2	6.9	1.6	5.8	6.9	2.9	2.9
Paper 2 ALL		15.6		10.9	11.2	10.7	10.8	9.4	6.7	6.1	6.5	4.5	3.1
Paper 3	69.2		30.8										



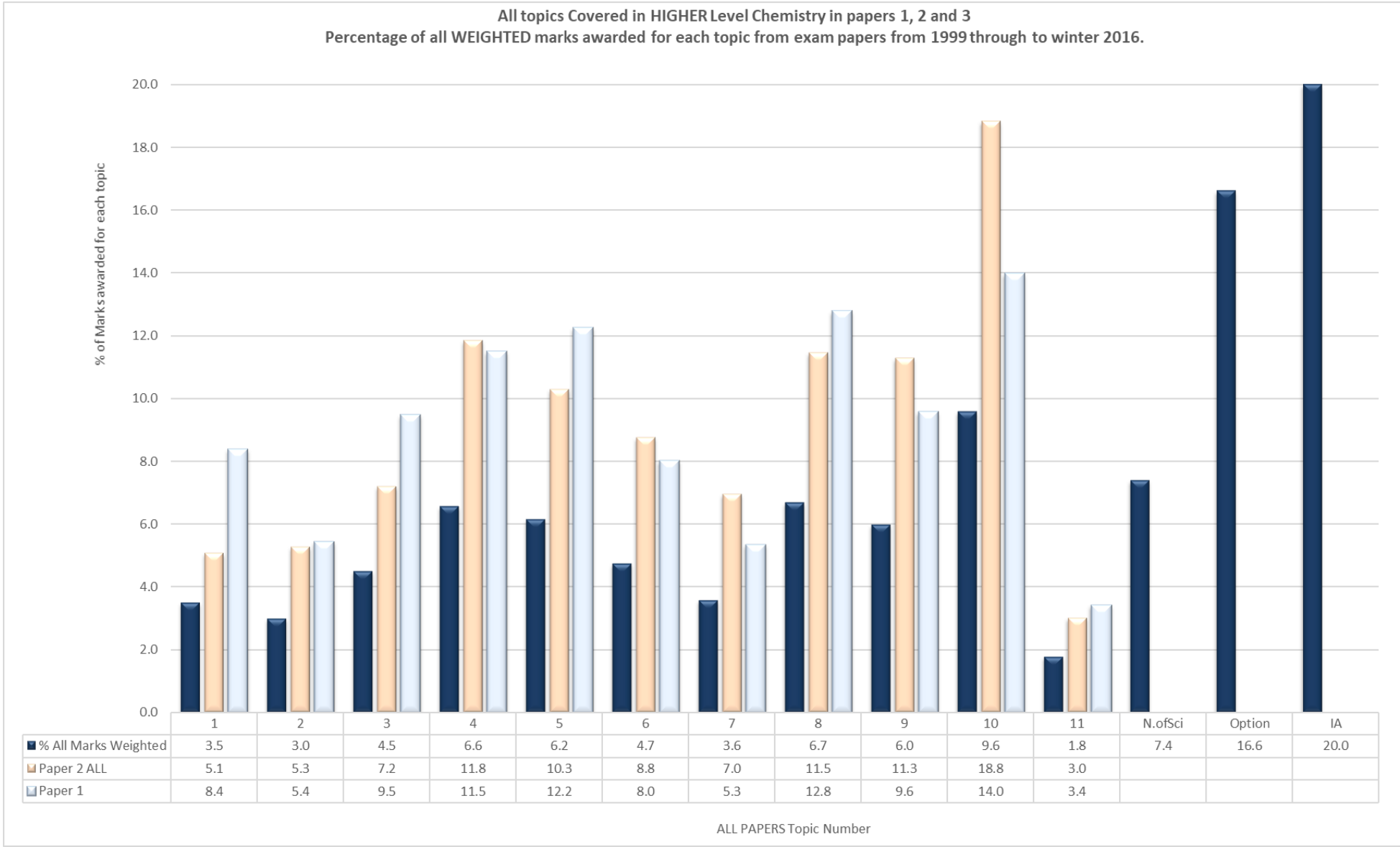


Standard and Higher Level components compared



	IA	Option	10	N.ofSci	8	4	5	9	6	3	7	1	2	11
SL	20.0	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
HL	20.0	16.6	9.6	7.4	6.7	6.6	6.2	6.0	4.7	4.5	3.6	3.5	3.0	1.8

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.



	1	2	3	4	5	6	7	8	9	10	11	N.ofSci	Option	IA
% All Marks Weighted	3.5	3.0	4.5	6.6	6.2	4.7	3.6	6.7	6.0	9.6	1.8	7.4	16.6	20.0
Paper 2 ALL	5.1	5.3	7.2	11.8	10.3	8.8	7.0	11.5	11.3	18.8	3.0			
Paper 1	8.4	5.4	9.5	11.5	12.2	8.0	5.3	12.8	9.6	14.0	3.4			

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 HL, 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.

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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(ii) State what can be determined from the frequency of the convergence limit. [1]

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

2. One of the main constituents of acid deposition is sulfuric acid, H_2SO_4. This acid is formed from the sulfur dioxide pollutant, SO_2.

(e) With reference to section 9 of the data booklet, explain the difference between the atomic radius and the ionic radius of nitrogen. *[1]*

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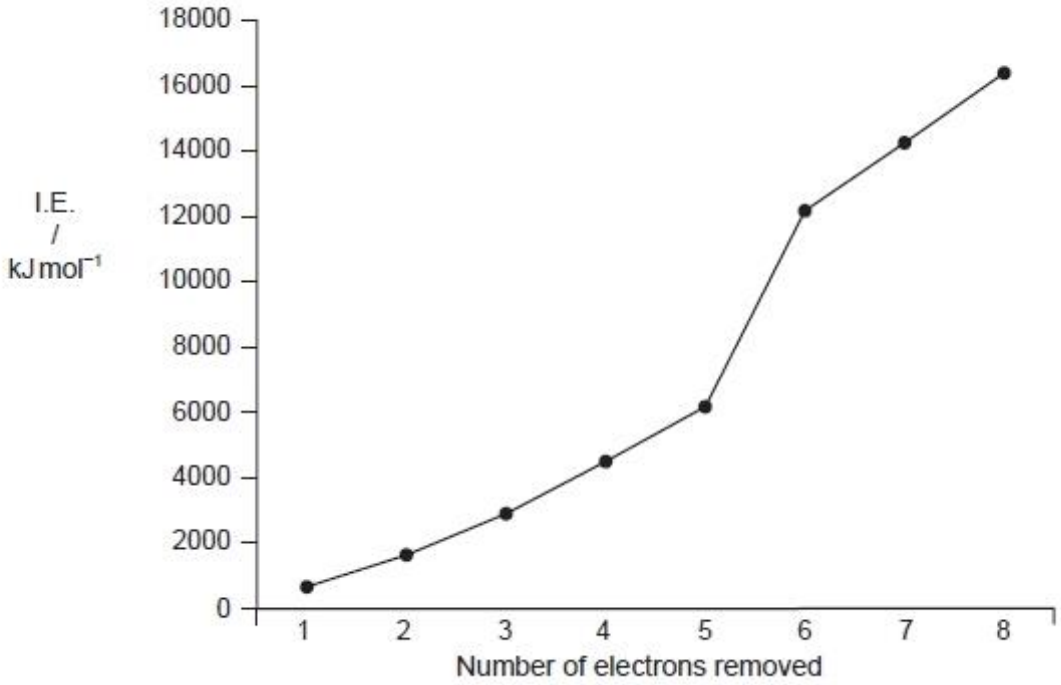
Q# 3/ IB Chem/2016/s/TZ1/Paper 2 Section A/Higher Level/Q4

(e) Eight successive ionisation energies of vanadium are shown in the graph below:



(i) State the sub-levels from which each of the first four electrons are lost. [1]

First: . . . . Second: . . . . Third: . . . . Fourth: . . . .

(ii) Outline why there is an increase in ionization energy from electron 3 to electron 5. [1]

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(iii) Explain why there is a large increase in the ionization energy between electrons 5 and 6. [3]

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

Q# 4/ 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]

Q# 5/ 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]*

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

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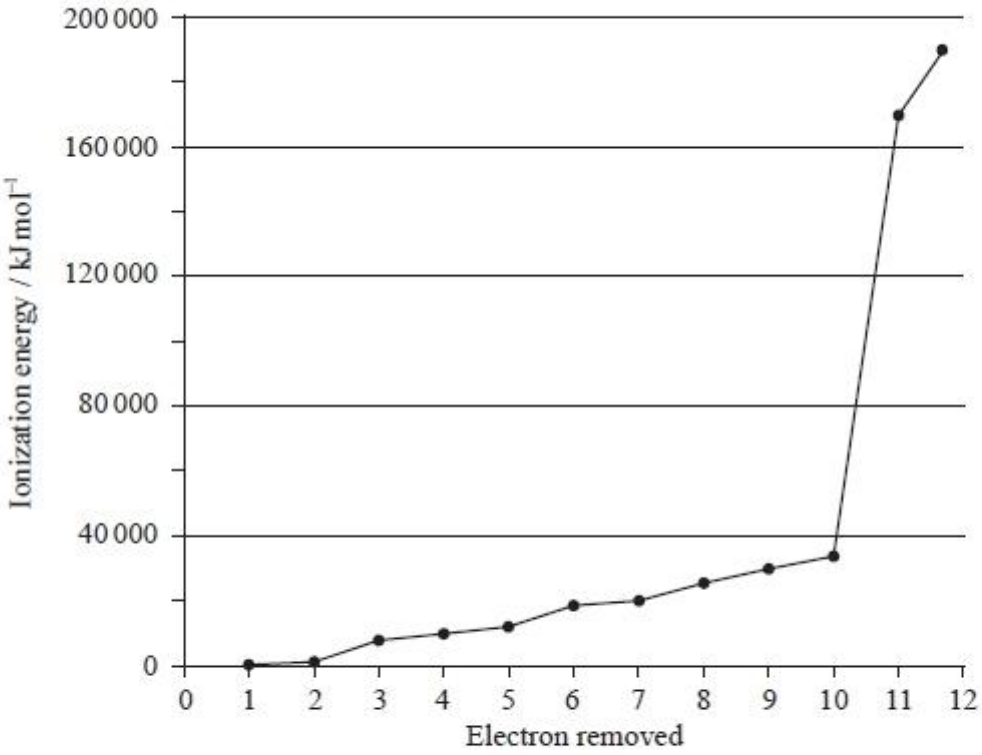
(b) A graph of the successive ionization energies of magnesium is shown below.



(i) Explain the increase in ionization energy values from the 3rd to the 8th electrons. *[1]*

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(ii) Explain the sharp increase in ionization energy values between the 10th and 11th electrons. *[2]*

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8. Magnesium, a reactive metal found in many common minerals, is also an essential nutrient for both plants and animals.

(a) Define the term *first ionization energy*. *[2]*

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(b) Successive ionization energies of magnesium are given in the table below.

	First	Second	Third
Energy required / kJ mol^{-1}	738	1450	7730

(i) Explain why the second ionization energy is greater than the first ionization energy. *[2]*

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(ii) Explain why the third ionization energy is **much** greater than the second ionization energy. *[2]*

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Q# 7/ 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# 8/ 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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Q# 9/ IB Chem/2013/s/TZ1/Paper 2 Section B/Higher 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]*

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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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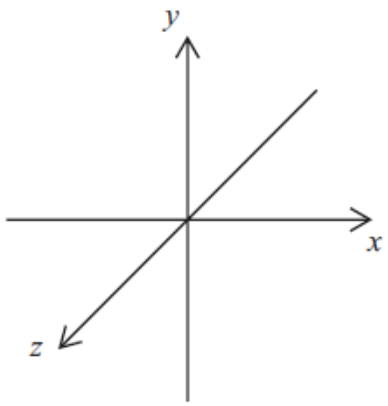
Q# 10/ IB Chem/2012/w/TZ0/Paper 2 Section A/Higher Level/Q2(a)

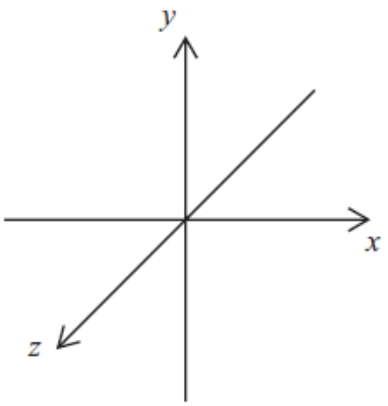
(ii) Lithium exists as two isotopes with mass numbers of 6 and 7. Deduce the number of protons, electrons and neutrons for each isotope. *[2]*

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]*



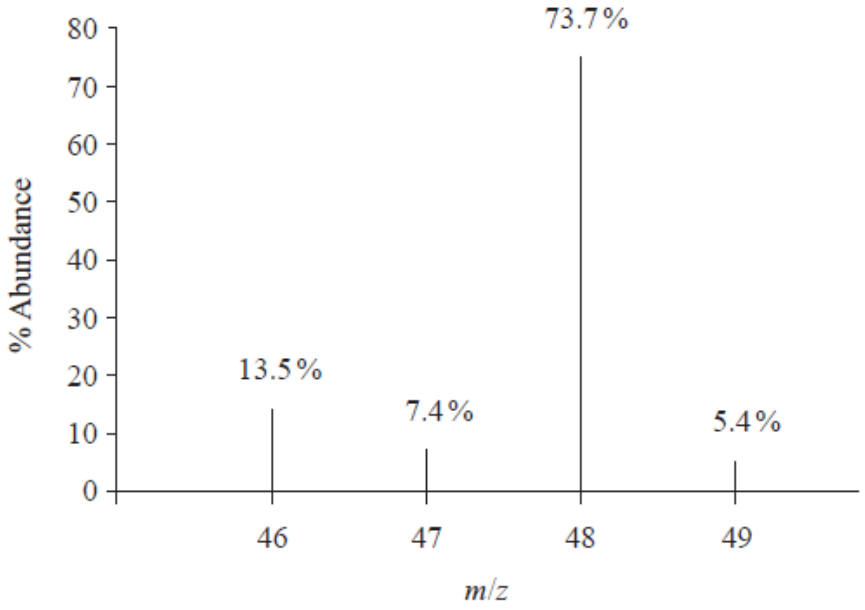
s orbital



p_x orbital

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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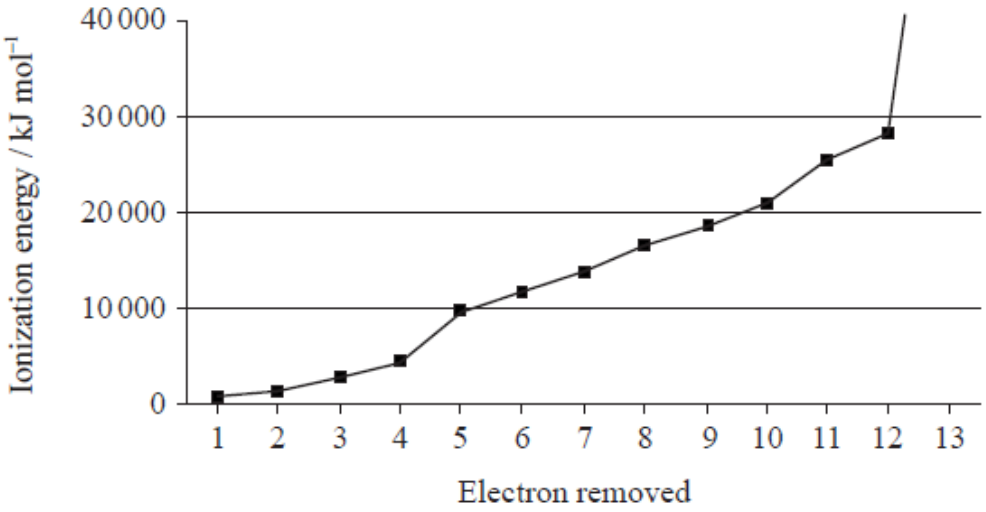
(b) The successive ionization energies of titanium are shown below.



(i) State the **full** electron configuration of an atom of titanium and identify the sub-level from which the electron is removed when the 1st ionization energy is measured. *[2]*

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(ii) Explain why there are relatively large differences between the 4th and 5th, **and** between the 10th and 11th ionization energies. *[3]*

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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# 12/ 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# 13/ IB Chem/2011/s/TZ1/Paper 2 Section A/Higher Level/

(d) Identify a radioactive isotope of cobalt **and** state **one** of its uses. *[1]*

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Q# 14/ 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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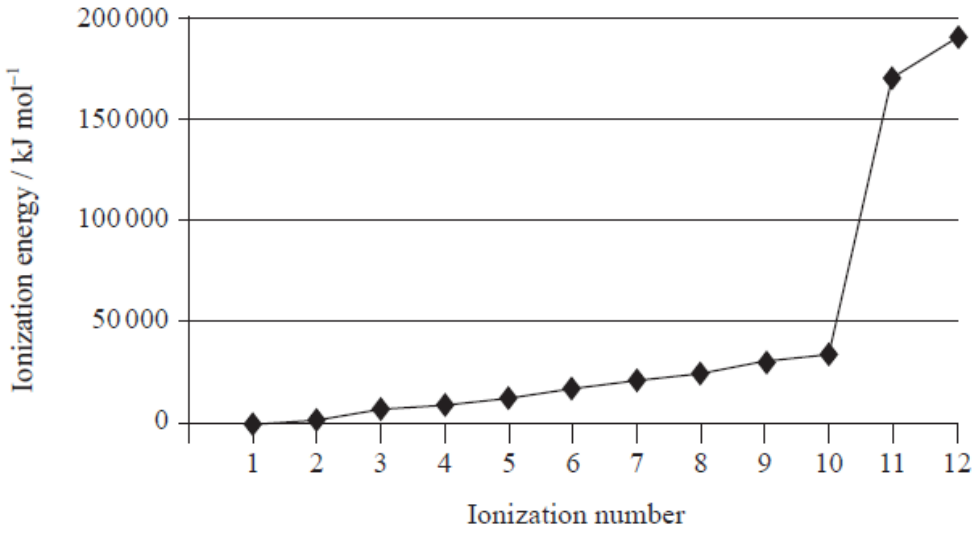
Q# 15/ IB Chem/2010/w/TZ0/Paper 2 Section B/Higher Level/

4. Magnesium is the eighth most abundant element in the earth's crust. The successive ionization energies of the element are shown below.



(a) (i) Define the term *first ionization energy* and state the equation for the first ionization of magnesium. *[3]*

(ii) Explain the general increase in successive ionization energies of the element. *[2]*

(iii) Explain the large increase between the tenth and eleventh ionization energies. *[3]*

Q# 16/ 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# 17/ 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# 18/ 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]*

(d) The isotopes of some elements are radioactive. State a radioisotope used in medicine. *[1]*

Q# 19/ 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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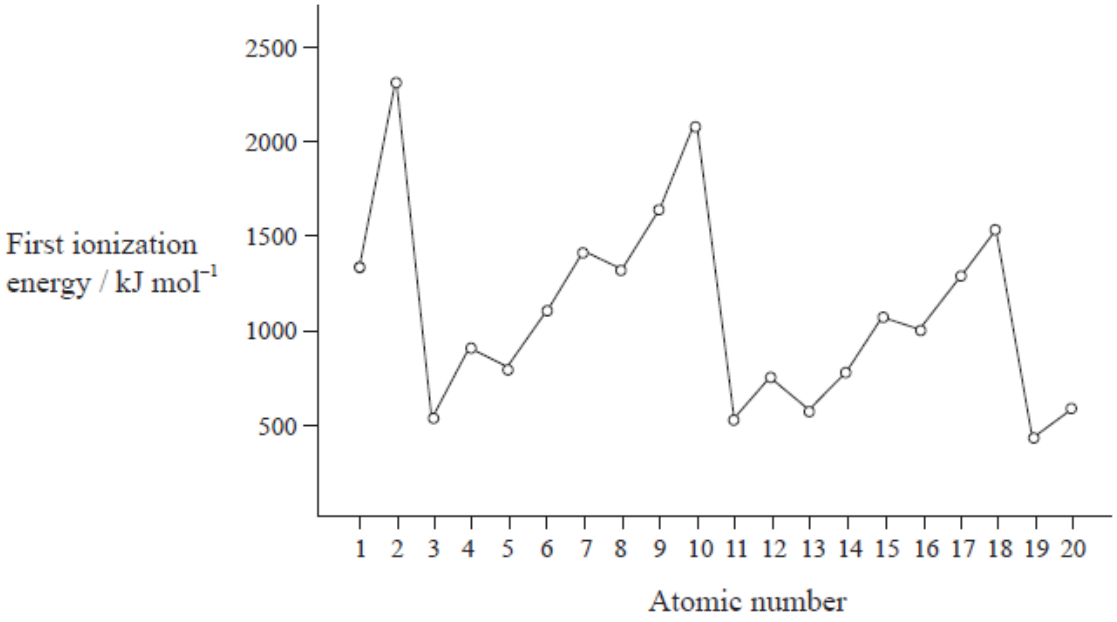
Q# 20/ IB Chem/2009/s/TZ1/Paper 2 Section B/Higher Level/Q8a

(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

(b) The graph of the first ionization energy plotted against atomic number for the first twenty elements shows periodicity.



(i) Define the term *first ionization energy* and state what is meant by the term *periodicity*. *[2]*

(ii) Explain how information from this graph provides evidence for the existence of main energy levels and sub-levels within atoms. *[4]*

(iii) State what is meant by the term *second ionization energy*. *[1]*

(iv) Sketch and explain the shape of the graph obtained for the successive ionization energies of potassium using a logarithmic scale for ionization energy on the *y*-axis against number of electrons removed on the *x*-axis. *[4]*

Q# 21/ 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# 22/ 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# 23/ IB Chem/2007/w/TZ0/Paper 2 Section B/Higher Level/

6. (a) Explain why sulfur has a lower first ionization energy than oxygen, and also a lower first ionization energy than phosphorus. *[4]*

Q# 24/ 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# 25/ 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# 26/ 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# 27/ IB Chem/2006/s/TZ0/Paper 2 Section B/Higher Level/Q7

(e) (i) Explain why the first ionization energy of magnesium is lower than that of fluorine. *[2]*

(ii) Write an equation to represent the third ionization energy of magnesium. Explain why the third ionization energy of magnesium is higher than that of fluorine. *[3]*

Q# 28/ 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]*

. . . . . .

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

. . . . . .

(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# 29/ 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]*

. . . . . .

. . . . . .

. . . . . .

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

. . . . . .

. . . . . .

. . . . . .

. . . . . .

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

. . . . . .

(d) The successive ionization energies of germanium are shown in the following table:

	1st	2nd	3rd	4th	5th
Ionization energy / kJ mol^{-1}	760	1540	3300	4390	8950

(i) Identify the sub-level from which the electron is removed when the first ionization energy of germanium is measured. *[1]*

. . . . . .

(ii) Write an equation, including state symbols, for the process occurring when measuring the second ionization energy of germanium. *[1]*

. . . . . .

(iii) Explain why the difference between the 4th and 5th ionization energies is much greater than the difference between any two other successive values. *[2]*

. . . . . .

. . . . . .

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. . . . . .

Q# 30/ 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# 31/ IB Chem/2004/s/TZ0/Paper 2 Section A/Higher Level/

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

. . . . . .

. . . . . .

. . . . . .

(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]*

. . . . . .

. . . . . .

. . . . . .

Q# 32/ 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]*

. . . . . .

. . . . . .

(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]*

. . . . . .

. . . . . .

Q# 33/ 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]*

. . . . . .

(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]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

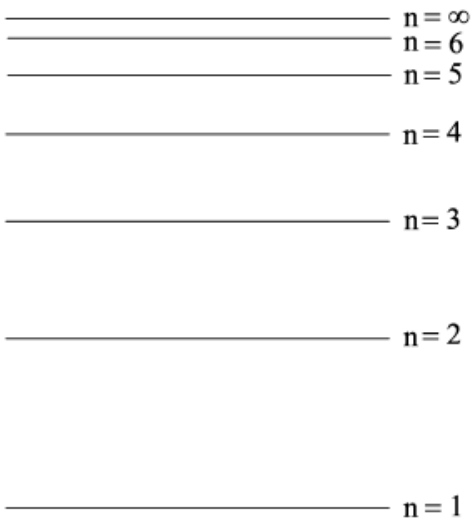
(c) State the complete electronic configuration of bromine, Br and the iron(III) ion, Fe^{3+}. *[2]*

Br: . . . . . .

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

Q# 34/ IB Chem/2003/s/TZ0/Paper 2 Section A/Higher Level/

2. (a) The diagram below (not to scale) represents some of the electron energy levels in the hydrogen atom.



(i) Draw an arrow on the diagram to represent the electron transition for the ionization of hydrogen. Label this arrow A. *[2]*

(ii) Draw an arrow on the diagram to represent the lowest energy transition in the visible emission spectrum. Label this arrow B. *[2]*

(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]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

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

NT_3: .....

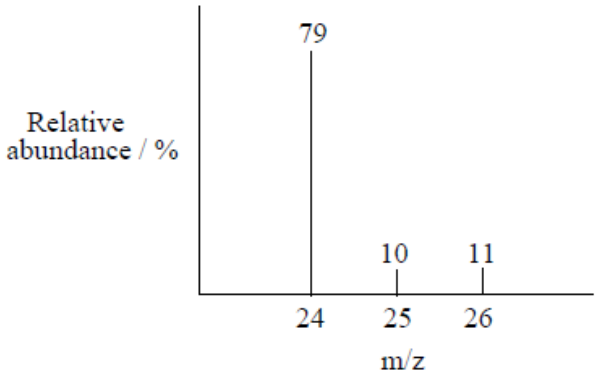
.....

NaOT: .....

.....

Q# 35/ 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]*

.....

.....

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

.....

.....

.....

.....

Q# 36/ 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]*

.....

.....

.....

.....

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

.....

Q# 37/ 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) (i) Describe how the first **four** ionisation energies of aluminium vary. (You may wish to sketch a graph to illustrate your answer.) *[2]*

(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# 38/ 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]*

. . . . . .

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

. . . . . .

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

. . . . . .

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

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

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

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Q# 39/ 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 2 HL P2 16w to 99s Section A&B 205marks

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
4.	d	ii	ionisation energy ✓		1

Q# 2/ IB Chem/2016/s/TZoSP/Paper 2 Section A/Higher Level/Q2

	e		ionic radius of nitrogen is 146pm/146×10^{-12} m which is greater than atomic radius which is 71pm/71×10^{-12} m due to increased repulsion between electrons ✓	*Values must be given to score mark.*	1

Q# 3/ IB Chem/2016/s/TZ1/Paper 2 Section A/Higher Level/

4.	e	i	*First*: 4s ***AND*** *Second*: 4s ***AND*** *Third*: 3d ***AND*** *Fourth*: 3d ✓	*Do **not** apply ECF from (c).*	1
4.	e	ii	«in the same sub-shell and a» decrease in electron-electron repulsion ***OR*** «in the same sub-shell and» as more electrons removed, the pull of of the nucleus/positive ions holds the remaining electrons more tightly ✓	*Do **not** accept "greater nuclear charge/ effective nuclear charge".*	1
4.	e	iii	electron 5 is lost from the 3d orbital ***OR*** electron 5 is lost from the valence shell ✓ electron 6 is lost from a 3p orbital ***OR*** electron 6 is lost from a «complete» inner shell ✓ 3p orbital/complete inner shell experiences a much larger effective nuclear charge ***OR*** 3p orbital/complete inner shell is less well shielded ***OR*** 3p orbital/complete inner shell is nearer the nucleus ✓	*Award **[1 max]** (for M1/M2) (ECF) if candidate recognises electrons 5 and 6 are from different levels.*	3
4.	e	iv	28 ✓		1

Q# 4/ 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# 5/ IB CHEM/2014/w/TZ0/Paper 2 Section B/Higher Level/

8. (a) (i) $\left(\frac{(77.44\times 24)+(10.00\times 25)+(12.56\times 26)}{100}\right)$;

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# 6/ IB CHEM/2014/s/TZ1/Paper 2 Section B/Higher Level/

8. (a) minimum energy required to remove one electron / energy required to remove most loosely bound/outermost electron;
from gaseous/isolated atom; *[2]*
Accept "gaseous state".
More extensive definitions involving one mole may be given.

(b) (i) electrons lost in same orbital/valence shell;
(second) electron/electron (being lost from Mg^+ is) closer to the nucleus;
(second) electron/electron (being lost from Mg^+) not subject to e-e repulsion from others in same level; *[2 max]*
Apply OWTTE for all marking points.
*Do **not** accept "less electrons to share the charge" or answers employing this concept.*

(ii) electron in lower energy level / more stable electron shell;
electron closer to nucleus;
less shielding by complete inner shells / increase in effective nuclear charge; *[2 max]*
Apply OWTTE for all marking points.

Q# 7/ IB Chem/2014/s/TZ2/Paper 2 Section A/Higher Level/

2. (a) $63x+65(100-x)=63.55\times 100$;

$(x=)72.50(\%)$; *[2]*

Award [2] for correct final answer.

Q# 8/ IB Chem/2014/s/TZ1/Paper 2 Section A/Higher Level/Q3

(b) $(A_r=)0.7899\times 24+0.1000\times 25+0.1101\times 26$;

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# 9/ 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# 10/ IB Chem/2012/w/TZ0/Paper 2 Section A/Higher Level/Q2

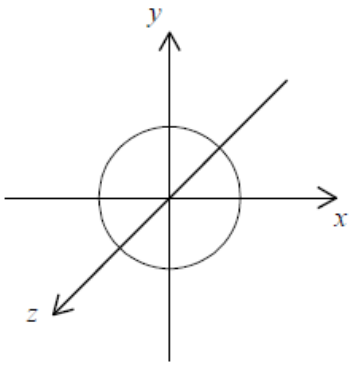
(ii)

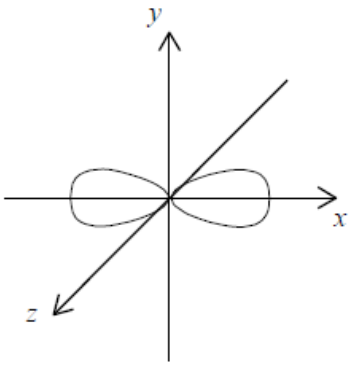
Mass number (A)	Number of protons	Number of electrons	Number of neutrons
6	3	3	3 ;
7	3	3	4 ;

[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# 11/ 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.

(iv) prevents collisions/unintentional deflections / *OWTTE*; *[1]*

(b) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^2$;
4s; *[2]*

(ii) 4^{th} electron removed from 3d **and** 5^{th} electron removed from 3p;
10^{th} electron removed from 3p **and** 11^{th} electron removed from 3s;

Accept either of the following answers for the third mark:
electrons removed from lower energy level / energy level closer to nucleus are attracted more strongly;
greater effective nuclear charge / s electrons more penetrating; ***[3 max]***

(iii) +2, +3, +4; ***[1]***

(iv) (colour) due to partially filled/incomplete d sub-level/orbital;
d sub-level is split / d orbitals are split;
$Ni^{2+}(aq)$ has incomplete 3d sub-level/orbital but $Sc^{3+}(aq)$ has no 3d electron/empty/d sub-level;
electrons move from lower to higher (sub)levels when they absorb energy/light;
$Ni^{2+}(aq)$ (appears green because it) absorbs red; ***[5]***

(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# 12/ 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# 13/ 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]***

(d) ^{60}Co/Co-60/cobalt-60 **and** radiotherapy/sterilization of medical supplies/radiation treatment of food sterilizations/industrial radiography/density measurements in industry/(medical/radioactive) tracer;
Allow treatment of cancer.
Do not allow "just used in medicine".

OR

^{57}Co/Co-57/cobalt-57 **and** medical tests/label for vitamin B_{12} uptake; ***[1 max]***
Do not allow "just used in medicine".

Q# 14/ 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# 15/ IB Chem/2010/w/TZ0/Paper 2 Section B/Higher Level/

4. (a) (i) energy (per mole) needed to remove one/first/most loosely bound electron from a (neutral) atom;
in the gaseous state;
$Mg(g) \rightarrow Mg^+(g) + e^-$; ***[3]***
Gaseous state symbols needed.
Accept e instead of e^-.
Only penalize omission of gas phase once in either the second marking point or the third marking point.

(ii) successive electrons (are more difficult to remove because each is) taken from more positively charged ion/ *OWTTE*;
increased electrostatic attraction; ***[2]***

(iii) 10th electron comes from 2nd energy level/$n = 2$ **and** 11th electron comes from 1st first energy level/$n = 1$ / *OWTTE*;
electron in 1st energy level closer to nucleus;
electron in 1st energy level not shielded by inner electrons / exposed to greater effective nuclear charge; ***[3]***

Q# 16/ 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# 17/ 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# 18/ 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 .*

(d) ^{60}Co/ ^{131}I/^{125}I; **[1]**
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.

Q# 19/ 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.

(b) $[Fe(CN)_6]^{4-} = +2$;
$[FeCl_4]^{-} = +3$; **[2]**
*Award **[1 max]** if 2+ and 3+, 2 and 3 or II and III stated.*

Q# 20/ IB Chem/2009/s/TZ1/Paper 2 Section B/Higher Level/Q8a

(iii) $A_r = \frac{[(0.56\times84)+(9.90\times86)+(7.00\times87)+(82.54\times88)]}{100}$;
$= 87.71$; **[2]**
*Award **[1 max]** if answer not given to two decimal places.*
Apply –1(U) if answer quoted in g or g mol^{-1}.

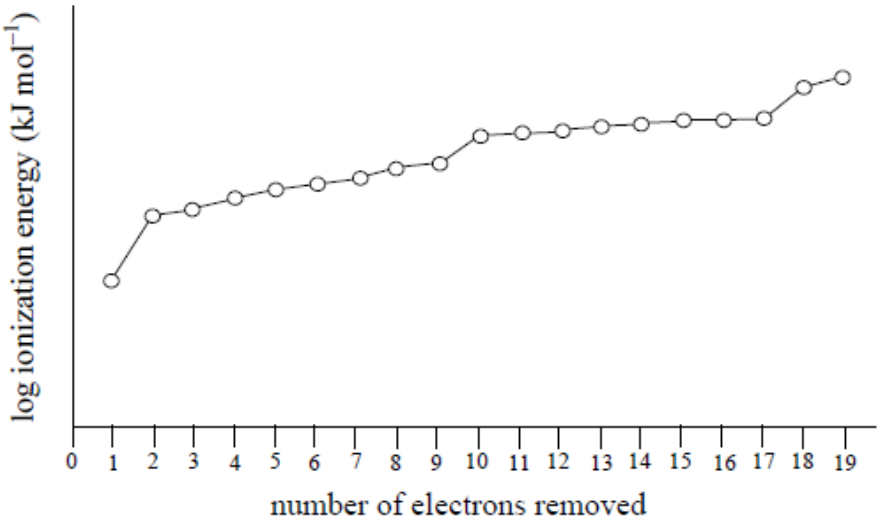
(b) (i) first ionization energy: $M(g) \rightarrow M^+(g) + e^-$/e / the (minimum) energy (in kJ mol^{-1}) to remove one electron from a gaseous atom / the energy required to remove one mole of electrons from one mole of gaseous atoms;
periodicity: repeating pattern of (physical and chemical) properties; **[2]**

(ii) (evidence for main levels)
highest values for noble gases / lowest values for alkali metals / *OWTTE*;
general increase across a period;
(evidence for sub-levels)
drop in I.E. from Be to B/Mg to Al/Group 2 to Group 3;
drop in I.E. from N to O/P to S/Group 5 to Group 6; **[4]**

(iii) $M^+(g) \rightarrow M^{2+}(g) + e^-$ / *OWTTE* ; **[1]**
Accept e instead of e^-.

(iv) Rough sketch to show:

Graph of successive ionization energies for potassium



correct use of axes **and** one electron relatively easy to remove;
a jump in value then eight, another jump to another eight **and** finally another jump for the remaining two electrons ;

electronic configuration of K=$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ / first electron due to removal of $4s^1$, next eight due to third level/$3s^2 3p^6$, next eight due to second level/$2s^2 2p^6$ and last two due to removal of first level/$1s^2$;
the more electrons removed the more the positive nucleus attracts the remaining electrons and each main energy level is closer to the nucleus / *OWTTE*; ***[4]***

Q# 21/ 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# 22/ 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# 23/ IB Chem/2007/w/TZ0/Paper 2 Section B/Higher Level/

6. (a) $IE_S < IE_O$:

valence electron in S in n=3, in O in n=2 / e^- further away / S has another electron shell / atomic radius of S greater than that of O;
less attracted to nucleus / experiences greater screening from inner electrons;

$IE_S < IE_P$:

electron removed from S is paired;
greater repulsion due to two electrons in the same (p) orbital / paired electrons in S; *[4]*

Q# 24/ IB Chem/2007/w/TZ0/Paper 2 Section A/Higher Level/

2. (a) (i) 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*; *[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) large 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# 25/ 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}Rb = 76.5 and ^{87}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# 26/ IB Chem/2006/w/TZ0/Paper 2 Section A/Higher Level/

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

Q# 27/ IB Chem/2006/s/TZ0/Paper 2 Section B/Higher Level/Q7

(e) (i) electron removed from higher energy level / further from nucleus / greater atomic radius;
increased repulsion by extra inner shell electrons / increased shielding effect; *[2]*

(ii) $Mg^{2+}(g) \rightarrow Mg^{3+}(g) + e$;
(even though) valence electrons in the same shell/main energy level / Mg^{2+} has noble gas configuration;
Mg has greater nuclear/core charge/more protons; *[3]*

Q# 28/ IB Chem/2006/s/TZ0/Paper 2 Section A/Higher Level/

2. (a) $A_r(Tl) = 203 \times 0.2952 + 205 \times 0.7048 / A_r(Tl) = 204.41$;
$A_r(Br) = 79 \times 0.5069 + 81 \times 0.4931 / A_r(Br) = 79.99$;
$M_r(TlBr_3) = 204.41 + 3 \times 79.99 = 444.38 / 444.37$; *[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 average 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# 29/ 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* $3d^{10}$.

(d) (i) (4)p; *[1]*

(ii) $Ge^+(g) \rightarrow Ge^{2+}(g) + e^-$; *[1]*

Do not penalize for $e^-(g)$.

Accept loss of electron on LHS.

(iii) 5th electron removed from energy level closer to nucleus/5th electron removed from 3rd energy level and 4th electron from 4th energy level/*OWTTE*;
attraction by nucleus or protons greater (for electrons closer to nucleus)/*OWTTE*; *[2]*

Q# 30/ 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# 31/ 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# 32/ 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# 33/ 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: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^5$ / $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^5$;

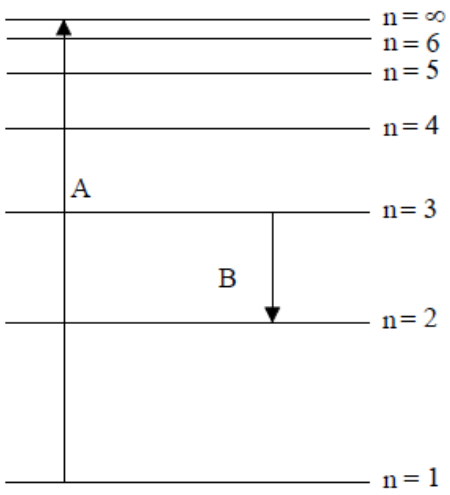
For Br, accept only complete configuration (which is asked for).

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

2.



(i) line starting at n = 1;
line finishing at n = ∞ (*not above* ∞);
upward arrow; ***[2 max]***
*3 correct **[2]**, 2 correct **[1]**.*

(iii) Line from n = 3 to n = 2;
Arrow pointing downward (*in any transition*); ***[2]***

(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# 35/ 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# 36/ 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]***

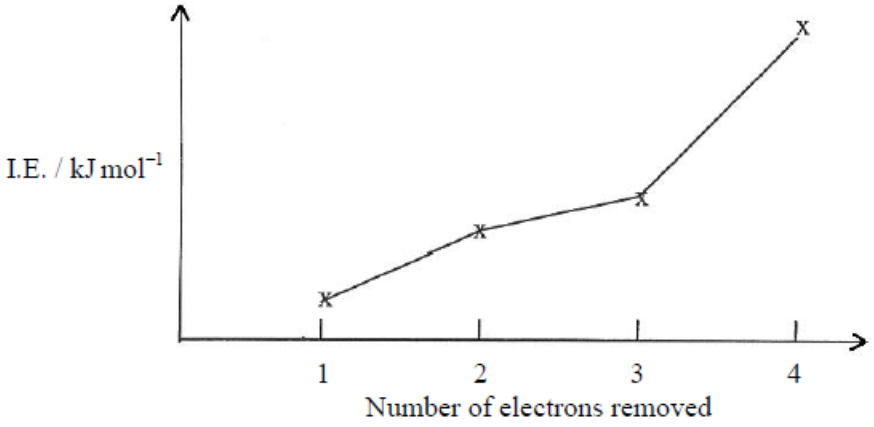
Q# 37/ IB Chem/2001/w/TZ0/Paper 2 Section B/Higher Level/

5. (a) (i) Average $A_r = \frac{(32.00\times95.00)+(33.00\times0.76)+(34.00\times4.20)+(36.00\times0.020)}{100}$ *[1]*

$= 32.1$ *[1]*

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

(b) (i)



*(Award **[1]** for increase from first to third I.E. and **[1]** for larger increase from third to fourth I.E.; for "I.E. keeps increasing" award only **[1]**)* *[2]*

(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# 38/ 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]*

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: $1s^2$