2.1 Atomic & Electronic Structure

Question Paper

Course	DP IB Chemistry
Section	2. Atomic Structure
Topic	2.1 Atomic & Electronic Structure
Difficulty	Medium

Time allowed: 60

Score: /42

Percentage: /100

Question 1a

a) Using your knowledge of atomic structure, complete **Table 1** below for the particles found in an atom.

Table 1

Particle	Relative charge	Relative mass
Proton		
Neutron		
Electron		

[3 marks]

Question 1b

b) The actual mass of protons, neutrons and electrons is given in **Table 2**.

Table 2

	Proton	Neutron	Electron
Mass (kg)	1.672622×10^{-27}	1.674927×10^{-27}	9.109383×10^{-31}

Calculate the mass, in g, of a nitrogen molecule.

[1 mark]

Question 1c

c) Oxygen consists of three stable isotopes, oxygen-16, oxygen-17, and oxygen-18. State the particles present in each isotope and outline what differences would be expected in the chemical reactivity of the three isotopes.

[2 marks]

Question 1d

d) Suggest why some elements have several isotopes and others, like fluorine, have only one known isotope (known as monoisotopic elements).

[1 mark]

Question 2a

a) Nitrous oxide is used as a sedative in dentistry and has the formula N_2O. Different sources of N_2O contain different ratios of ^{14}N and ^{15}N.

State the name of the instrument used to distinguish between ^{14}N and ^{15}N and outline two characteristic differences seen in the analysis of ^{14}N and ^{15}N.

[2 marks]

Question 2b

b) A sample of nitrous oxide was enriched so that it contained 4% by mass of ^{15}N. Calculate the relative molecular mass of the resulting nitrous oxide.

[2 marks]

Question 2c

c) Predict and explain, giving two reasons, how the first ionization energy of ^{15}N would be different to ^{14}N.

[3 marks]

Question 2d

d) An atom has twice as many protons, and twice as many neutrons, as an atom of ^{15}N. Determine the chemical symbol for this atom, including the mass number, and deduce the number of electrons.

[2 marks]

Question 3a

a) The element chromium has several naturally occurring isotopes whose abundances are shown in **Table 1**.

Table 1

Mass number	% abundance
50	4.345
52	83.789
53	9.501
54	2.365

Calculate the relative atomic mass of chromium to two decimal places.

[2 marks]

Question 3b

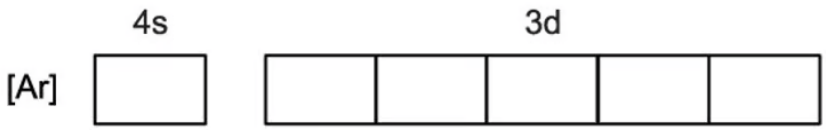
b) State the full electron configuration for chromium.

[1 mark]

Question 3c

c) State the meaning of **[Ar]** and complete the orbital diagram shown below for chromium.

Figure 1



[2 marks]

Question 3d

d) This question is about the chromium(III) ion, $^{52}_{24}Cr^{3+}$.

i) State the number of protons, electrons, and neutrons in the chromium(III) ion.

ii) Write the full electron configuration for the chromium(III) ion.

[2 marks]

Question 4a

a) This question is about line emission spectra of elements.

i) Explain the difference between a *continuous spectrum* and a *line spectrum.*

ii) Draw a labelled diagram that shows electron transitions in a hydrogen atom in the ultraviolet and visible regions of the electromagnetic spectrum. Include three electron transitions for each region.

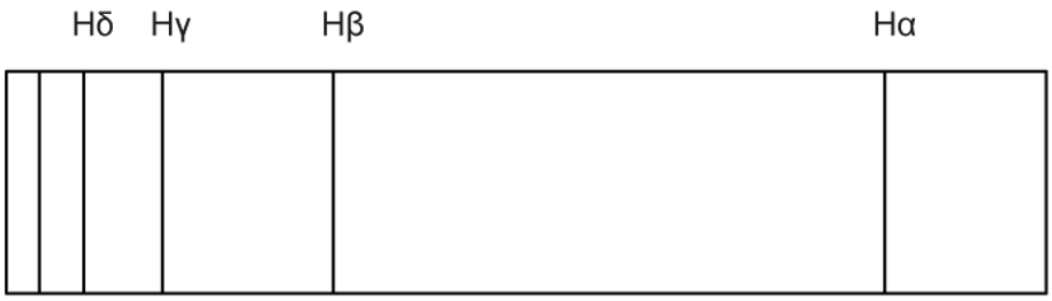
[6 marks]

Question 4b

b) The visible line emission spectrum of hydrogen is shown below in **Figure 1** and the wavelengths of the first four lines are listed in **Table 1**.

i) Use the information provided and Sections 1 and 2 of the IB data booklet to determine the frequency of the red line.

Figure 1



The visible line emission spectrum hydrogen

Table 1

Balmer spectral line	Wavelength in nm	Colour
Hα	656	Red
Hβ	486	Blue(cyan)
Hγ	434	Blue
Hδ	410	Violet

ii) Which spectral line carries more energy, Hα or Hδ?

[2 marks]

Question 4c

c) Draw the shape of a 1s atomic orbital and 2p atomic orbital.

[1 mark]

Question 4d

d) Describe the relationship between colour, energy, frequency, and wavelength in the visible spectrum.

[2 marks]

Question 5a

a) Electron configurations give you a summary of where you can find an electron around the nucleus of an atom. They can also be determined for an ion after an atom loses or gains electrons.

i) State the full electron configuration of the rubidium ion, $^{85}_{37}Rb^{+}$.

ii) State and explain the relative size of a rubidium ion compared to a krypton atom.

[3 marks]

Question 5b

b) The element rubidium has two naturally occurring isotopes of ^{85}Rb and ^{87}Rb. The relative atomic mass of rubidium is 85.47. Calculate the percentage abundance of each isotope.

[2 marks]

Question 5c

c) The electrons in an atom are found in orbitals around the nucleus, which have different energy levels sometimes called shells.

i) The fourth shell consists of the atomic orbitals 4d, 4f, 4p and 4s. List these orbitals in order of increasing energy.

ii) State the number of atomic orbitals present in 4d, 4f, 4p and 4s.

[2 marks]

Question 5d

d) Rubidium forms an ionic compound with selenium, Rb_2Se. Using boxes to represent orbitals and arrows to represent electrons, sketch the orbital diagram of the **valence shell** of selenium on the axis provided.

Figure 1

[1 mark]