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SL Score

HL Score

/38

/52

Practice Exam: Paper 2

Topic 2: Atomic Structure

SL

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

Argon has a greater proportion of heavier isotopes with more neutrons than potassium.

(1)

- (b) Deduce the numbers of protons and electrons in the K^+ ion.

protons = 19 electrons = $19 - 1 = 18$

(1)

- (c) Deduce the electron ^{configuration} ~~arrangement~~ for the K^+ ion.

$[Ne]3s^23p^6$

(1)

(Total 3 marks)

2. Rubidium contains two stable isotopes, ^{85}Rb and ^{87}Rb . The relative atomic mass of rubidium is given in Table 5 of the Data Booklet.

- (a) Calculate the percentage of each isotope in pure rubidium. State your answers to **three** significant figures.

$$85x + 87(1-x) = 85.47$$

$$85x + 87 - 87x = 85.47$$

$$2x = 1.53$$

$$x = 0.765$$

therefore
76.5% ^{85}Rb
23.5% ^{87}Rb (2)

- (b) The percentage of each isotope can be checked experimentally using a mass spectrometer. A vaporized sample of pure rubidium is ionized and then accelerated in a mass spectrometer. Outline how the use of a magnetic field and a detector in the mass spectrometer enables the percentages of the two isotopes to be determined.

The vaporized ions are deflected by the magnetic field, with the lighter $^{85}Rb^+$ ions deflected more than the heavier $^{87}Rb^+$ ions. At the detector there will be a greater (higher) peak for the more abundant ion.

must say ion!

(3)

(c) State the number of electrons and the number of neutrons present in an atom of ^{87}Rb .

Number of electrons:

37

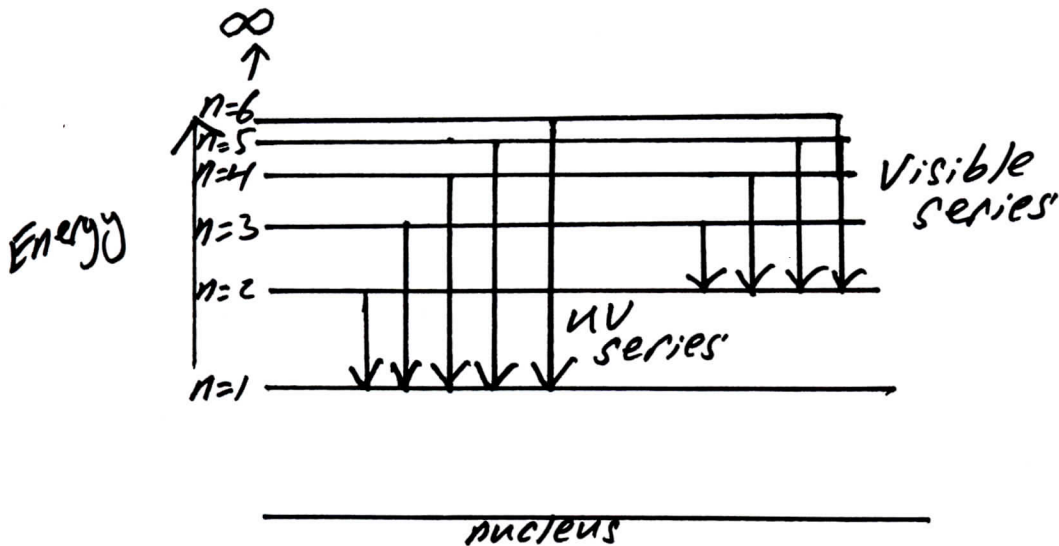
Number of neutrons:

$87 - 37 = \underline{50}$

(2)

(Total 7 marks)

3. Draw and label an energy level diagram for the hydrogen atom. In your diagram show how the series of lines in the ultraviolet and visible regions of its emission spectrum are produced, clearly labeling each series.



(Note: only need a few lines for each series!)

(Total 4 marks)

4. (a) List the following types of electromagnetic radiation in order of increasing wavelength (shortest first).

I. Yellow light

II. Red light

III. Infrared radiation

IV. Ultraviolet radiation

Ultraviolet radiation < yellow light < red light < Infrared radiation

= decreasing energy

(1)

(b) Distinguish between a continuous spectrum and a line spectrum.

A continuous spectrum contains all colors (wavelengths, frequencies, energies) of visible light, whereas a line spectrum contains only specific colors (wavelengths, frequencies, energies).

- (c) The thinning of the ozone layer increases the amount of UV-B radiation that reaches the Earth's surface.

Type of Radiation	Wavelength / nm
UV-A	320–380
UV-B	290–320

Based on the information in the table above explain why UV-B rays are more dangerous than UV-A.

UV-B radiation has shorter wavelengths, therefore has higher energy and is more likely to damage skin cells (and/or cause cancer).

(3)
(Total 5 marks)

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

$$30(0.031) + 29(0.969 - x) + 28x = 28.09$$

$$0.930 + 28.101 - 29x + 28x = 28.09$$

$$x = \boxed{94.1\%}$$

* (Round only once at the end!)

(Total 2 marks)

6. Identify a radioactive isotope of carbon and state one of its uses.

Carbon-14 used for radiodating.

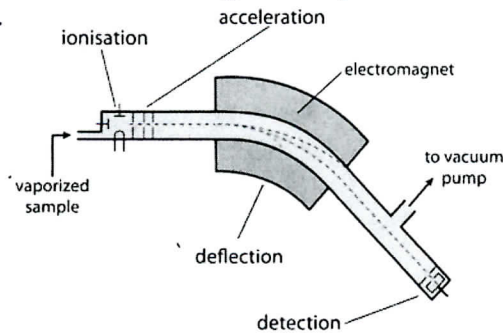
(Total 1 mark)

7. (a) Define the term relative atomic mass (A_r).

The weighted average mass of an atom compared to the carbon-12 isotope.

(1)

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



(5)

- (c) State three factors that affect the degree of deflection of ions in a mass spectrometer.

(3)

must include! $\left[\begin{array}{l} \bullet \text{ charge} \\ \bullet \text{ mass} \end{array} \right.$

either one ok! $\left\langle \begin{array}{l} \bullet \text{ strength of magnetic field} \\ \bullet \text{ velocity (speed) of ions} \end{array} \right.$

(Total 9 marks)

8. The relative atomic mass of naturally occurring copper is 63.55. Calculate the abundances of ^{63}Cu and ^{65}Cu in naturally occurring copper.

$$63(x) + 65(1-x) = 63.55$$

$$2x = 1.45$$

$$x = 0.725$$

(Total 2 marks)

Therefore
72.5% ^{63}Cu
27.5% ^{65}Cu

9. Iron has three main naturally occurring isotopes which can be investigated using a mass spectrometer.

The first stage in the operation of the mass spectrometer is vaporization. The iron is then ionized.

- (i) Explain why the iron is ionized.

The iron atoms must be ionized to be accelerated by the electric field and deflected by the magnetic field.

(2)

- (ii) Explain why a very low pressure is maintained inside the mass spectrometer.

prevents collisions among the ions.

(1)

(Total 3 marks)

10. 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.

$$0.0595(54) + 0.9188(56) + 0.0217(57) = 55.90$$

→ No units!

(Total 2 marks)

HL

1. (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.

cobalt has a greater proportion of heavier isotopes with more neutrons than nickel.

(1)

- (b) Deduce the numbers of protons and electrons in the ion Co^{2+} .

protons = 27 electrons = 27 - 2 = 25

(1)

- (c) Deduce the electron configuration for the ion Co^{2+} .

[Ar] 3d⁷

(1)

- (d) Identify a radioactive isotope of cobalt and state one of its uses.

cobalt-60 is used in radiotherapy to treat and kill cancer.

(1)

(Total 4 marks)

2. The electron configuration of chromium can be expressed as $[\text{Ar}]4s^x3d^y$.

- (i) Explain what the square brackets around argon, [Ar], represent.

The electron configuration of argon, 1s²2s²2p⁶3s²3p⁶.

(1)

- (ii) State the values of x and y.

x: *1* y: *5*

Recall Chromium is an exception to the aufbau principle!

(1)

- (iii) Annotate the diagram below showing the 4s and 3d orbitals for a chromium atom using an arrows to represent spinning electron.



4s

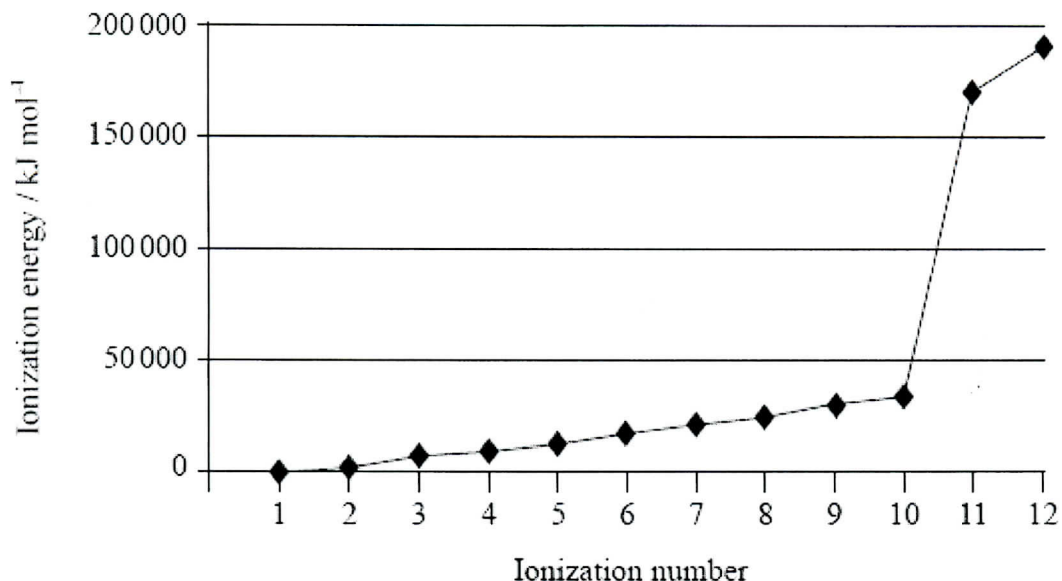


3d

(1)

(Total 3 marks)

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



- (i) Define the term *first ionization energy* and state the equation for the first ionization of magnesium.

The energy needed to remove the outermost electron from one mole of gaseous atoms.

(2)

- (ii) Explain the general increase in successive ionization energies of the element.

Each successive electron is being removed from a more positively charged ion.

(2)

- (iii) Explain the large increase between the tenth and eleventh ionization energies.

The 11th electron...

- is in the 1st energy level and closer to the nucleus.*
- is not shielded from the nucleus by core electrons.*

(3)

(Total 7 marks)