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IGCSE PHYSICS 0625 · TOPICAL PAST PAPERS

The Nuclear Model of the Atom — Paper 2

Worked Solutions (Theory / Structured)

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The Nuclear Model of the Atom — Paper 2 · Worked Solutions

Megalecture worked solutions — model answers with working; please verify before classroom use. These solutions cover the topical structured (Theory, Paper 2) compilation on **The Nuclear Model of the Atom (IGCSE Physics 0625)**. Each answer was solved from first principles by the Megalecture team: nuclide notation is read as ${}^{A}_{Z}\mathrm{X}$, where Z is the proton (atomic) number and A is the nucleon (mass) number, so number of neutrons = $A - Z$, and a neutral atom has number of electrons = Z. Final answers are shown in **bold**.

Question 1

May/June 2003 · P2 · Q8

Hydrogen has isotopes ${}^{1}_{1}\mathrm{H}$, ${}^{2}_{1}\mathrm{H}$ and ${}^{3}_{1}\mathrm{H}$.

(a) State the number of protons and neutrons in the two other isotopes.

${}^{2}_{1}\mathrm{H}$ → protons = Z = **1 proton**; neutrons = $A - Z$ = 2 − 1 = **1 neutron**.

${}^{3}_{1}\mathrm{H}$ → protons = Z = **1 proton**; neutrons = 3 − 1 = **2 neutrons**.

Question 2

May/June 2004 · P2 · Q8

The nucleon number of ${}^{220}_{86}\mathrm{Rn}$ is 220.

(d) Define *nucleon number*.
The nucleon number is the **total number of protons and neutrons in the nucleus** of an atom (the number of nucleons).

(e) Radon (${}^{220}_{86}\mathrm{Rn}$) emits an alpha-particle. State the proton number and nucleon number of the nucleus left behind.

An alpha-particle is ${}^{4}_{2}\mathrm{He}$ (2 protons + 2 neutrons), so the nucleus loses 2 from Z and 4 from A:

proton number = 86 − 2 = **84** nucleon number = 220 − 4 = **216**

Question 3

May/June 2007 · P2 · Q8

(a) Explain how an element can have different isotopes.
Atoms of the same element always have the **same number of protons** (same proton number), but can have **different numbers of neutrons**, giving different nucleon (mass) numbers.

Question 4

May/June 2009 · P2 · Q8

$^{238}_{92}\mathrm{U}$ has nucleon number 238 and proton number 92.

(a) State the meaning of *nucleon number*.
The nucleon number is the **total number of nucleons** in the nucleus, i.e. the **number of protons + number of neutrons** (here 238 = 92 protons + 146 neutrons).

Question 5

May/June 2014 · P21 · Q8

A radioactive isotope of iodine, $^{131}_{53}\mathrm{I}$.

(a)(i) Describe the structure of the nucleus of this atom.
The nucleus contains **53 protons** and **131 − 53 = 78 neutrons** (held tightly together at the centre of the atom). Total nucleons = 131.

Question 6

May/June 2014 · P22 · Q8

An atom is electrons surrounding a nucleus of protons and neutrons. State which particles…

(a)(i) have an equal and opposite charge → **the proton and the electron** (proton +e, electron −e).

(a)(ii) have almost equal mass → **the proton and the neutron** (each ≈ 1 atomic mass unit; the electron is far lighter).

Question 7

May/June 2015 · P22 · Q8

Two isotopes of hydrogen: $^{1}_{1}\mathrm{H}$ and $^{2}_{1}\mathrm{H}$.

(a) Complete the table (protons = Z, neutrons = $A - Z$):

	number of protons	number of neutrons
$^{1}_{1}\mathrm{H}$	**1**	**0**
$^{2}_{1}\mathrm{H}$	**1**	**1**

(b) Explain why atoms of $^{1}_{1}\mathrm{H}$ and $^{2}_{1}\mathrm{H}$ are uncharged.
Each atom has **1 proton** (charge +e) in the nucleus and **1 electron** (charge −e) outside it. The number of electrons equals the number of protons, so their **charges are equal and opposite and cancel**. The neutron carries **no charge**, so it does not affect the total. The atom is therefore neutral overall.

Question 8

Oct/Nov 2009 · P2 · Q8

(a)(i) Electrons in a neutral atom of $^{7}_{3}\mathrm{Li}$ = electrons = Z = **3**

(a)(ii) Nucleons in $^{208}_{82}\mathrm{Pb}$ = nucleon number = **208**

(a)(iii) Protons in $^{23}_{11}\mathrm{Na}$ = proton number = **11**

(b) Isotopes chlorine-35 and chlorine-37 (chlorine-35 has 17 protons). Isotopes have the **same proton number**, so for chlorine-37:

(b)(i) protons = **17** **(b)(ii)** neutrons = 37 − 17 = **20**

Question 9

Oct/Nov 2012 · P22 · Q8

Four neutral nuclei: $^{12}_{6}\mathrm{C}$, $^{14}_{6}\mathrm{C}$, $^{14}_{7}\mathrm{N}$, $^{15}_{8}\mathrm{O}$. (neutrons: 6, 8, 7, 7)

(a) Greatest number of electrons = greatest proton number = Z = 8 → $\mathbf{^{15}_{8}O}$.

(b)(i) Same number of protons (same Z = 6) → $\mathbf{^{12}_{6}C}$ **and** $\mathbf{^{14}_{6}C}$.

(b)(ii) Same number of nucleons (same A = 14) → $\mathbf{^{14}_{6}C}$ **and** $\mathbf{^{14}_{7}N}$.

(b)(iii) Same number of neutrons ($A - Z$ = 7) → $\mathbf{^{14}_{7}N}$ **and** $\mathbf{^{15}_{8}O}$.

Question 10

Oct/Nov 2014 · P21 · Q8

Boron-12, nuclide notation $^{12}_{5}\mathrm{B}$.

(a) Draw a labelled diagram of a neutral atom of this isotope, showing all particles.

A neutral atom of $^{12}_{5}\mathrm{B}$ contains, in a small central nucleus, **5 protons** and **12 − 5 = 7 neutrons**, with **5 electrons** orbiting outside the nucleus. A correct diagram shows:

- **Nucleus:** 5 protons (+) and 7 neutrons (labelled) clustered together at the centre.
- **Electrons:** 5 electrons (−) shown orbiting / in shells around the nucleus.
- All three particle types clearly labelled (proton, neutron, electron).

Question 11

Oct/Nov 2016 · P22 · Q7

Plutonium-238, nuclide notation $^{238}_{94}\mathrm{Pu}$.

(a) Describe the structure and composition of a neutral atom of plutonium-238.

It has a **small, dense, positively charged central nucleus** containing **94 protons** and **238 − 94 = 144 neutrons** (238 nucleons in total). Around the nucleus, **94 electrons** orbit (move) in the mostly empty space of the atom. The atom is neutral because the number of electrons (94) equals the number of protons (94), so the charges balance.

Question 12

May/June 2019 · P22 · Q11

Uranium-235 ($^{235}_{92}\mathrm{U}$) is formed in an exploding star.

(b)(i) Name and number of each type of particle in one nucleus of $^{235}_{92}\mathrm{U}$:

protons — 92 (proton number) and **neutrons — 235 − 92 = 143**. (Electrons are not part of the nucleus.)

(b)(ii) One feature the same for all isotopes of uranium: they all have the **same number of protons (proton number = 92)**.

(c) Geiger and Marsden alpha-scattering experiment (alpha-particles fired at thin gold foil in a vacuum; a flash is seen where an alpha-particle hits the fluorescent screen).

(c)(i) Most flashes occur where the beam passes **straight through, undeflected**, so **P is marked directly behind the foil, in line with the incoming beam** (on the far side of the screen).

(c)(ii) On other parts of the screen, **a few isolated flashes** are seen — some alpha-particles are deflected through **large angles**, and a very few are **bounced almost straight back**.

(c)(iii) Two conclusions about gold atoms:

- Most of the atom is **empty space** (most alpha-particles pass straight through undeflected).
- The atom has a **tiny, dense, positively charged nucleus** that contains most of the atom's mass (it repels and deflects the few alpha-particles that come close, even sending some back).

Question 13

May/June 2020 · P21 · Q7

Isotopes carbon-12 and carbon-14 (carbon-14 is radioactive). Carbon-12 has proton number 6 and nucleon number 12.

(b) Complete the table for a neutral atom of each isotope (protons = electrons = Z = 6; neutrons = A − 6):

	carbon-12	carbon-14
number of protons	6	**6**
number of neutrons	**6**	**8**
number of electrons	**6**	**6**

Question 14

May/June 2020 · P22 · Q7

Radon-222 decay series P → Q → R → S → T → U on a proton-number / nucleon-number grid. P = radon-222 (Z=86, A=222); R and U sit at Z=82.

(a)(i) Two points that represent isotopes of the same element have the **same proton number**. On the grid **R and U are both at proton number 82**, so → **R and U**.

(a)(ii) How the composition of atoms of different isotopes differs: they have the **same number of protons but different numbers of neutrons** (so different nucleon numbers).

Question 15

Oct/Nov 2019 · P21 · Q7

Table 7.1 gives five particles P, Q, R, S, T (electron charge = -1.6×10^{-19} C):

	P	Q	R	S	T
number of electrons	17	18	18	19	20
number of neutrons	20	20	24	23	21
number of protons	17	19	18	19	20

(a)(i) The ionised atom has electrons ≠ protons. Only **Q** differs (18 electrons, 19 protons) → **Q**.

(a)(ii) Q has one more proton than electron, so it is missing one electron. Net charge = +1 elementary charge:

charge = $+1 \times 1.6 \times 10^{-19}$ C = **$+1.6 \times 10^{-19}$ C (positive)**

(b) Isotopes of the same element have the **same proton number**. Q and S both have 19 protons → **Q and S**.

Question 16

Oct/Nov 2020 · P22 · Q6

Phosphorus-32 ($^{32}_{15}\mathrm{P}$) is a radioactive isotope of phosphorus-31.

(a)(i) Describe the structure and composition of a neutral atom of phosphorus-31.

It has a **small central nucleus** containing **15 protons** and **31 − 15 = 16 neutrons**, with **15 electrons** orbiting around the nucleus. The number of electrons equals the number of protons, so the atom is **electrically neutral**.

(a)(ii) How an atom of phosphorus-32 differs from one of phosphorus-31: a phosphorus-32 atom has **one more neutron** (16 + 1 = **17 neutrons**); the numbers of protons (15) and electrons (15) are **unchanged**.

Note from Megalecture. These are original Megalecture worked solutions prepared for revision use, solved independently from the question data. Read nuclide symbols as $^{A}_{Z}\mathrm{X}$: protons = Z, neutrons = $A - Z$, and electrons = Z in a neutral atom. Please verify before classroom use.