Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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The nuclear atom

Time allowed: 1 hour 5 minutes

Subject code **0625**

Physics

Questions from Paper 3 and Paper 4

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

/ 66

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

Information

- This paper has 10 questions worth 66 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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Print at 100% (Actual size) so diagrams keep their real measurements.

1 Fig. 12.1 is a very simple representation of the structure of an atom.

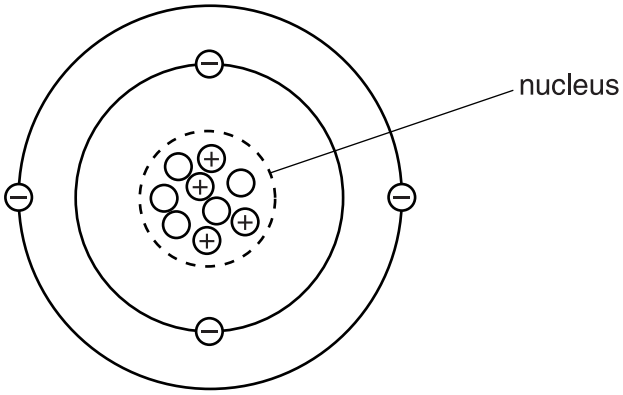


Fig. 12.1

The broken circle indicates the nucleus, and the particles inside this broken circle are the particles in the nucleus.

Charged particles are marked + or –. Uncharged particles are shown as empty circles.

(a) State the number of neutrons in this atom. ..... [1]

(b) State

(i) the nucleon number of the atom, ...

(ii) the proton number of the atom. .....
[2]

(c) What name is given to the negatively-charged particles? ..... [1]

[Total: 4]

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1 **(a)** 5 B1

(b) **(i)** 9 B1

(ii) 4 B1

(c) electrons B1

[Total: 4]

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2 **(a)** Atoms are composed of protons, neutrons and electrons.

(i) Which of these particles has the smallest mass?

.....

(ii) Which two of these types of particle are found in the nucleus?

..... and .....

[2]

(b) Naturally-occurring chlorine gas contains two types of atom.

These are $^{35}_{17}Cl$ and $^{37}_{17}Cl$.

(i) What does the number 17 tell us about the nuclei of chlorine atoms?

.....[1]

(ii) Which particle does an atom of $^{37}_{17}Cl$ contain more of than an atom of $^{35}_{17}Cl$?

.....[1]

(iii) State the number of electrons in a neutral atom of

1. $^{35}_{17}Cl$, ...

2. $^{37}_{17}Cl$. .....

[2]

[Total: 6]

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2 **(a)** **(i)** electron B1

(ii) proton and neutron (both, either order) B1

(b) **(i)** (number of) protons accept proton number
NOT no. of protons and electrons B1

(ii) neutron(s) B1

(iii) **1.** 17, accept 2, 8, 7 B1

2. 17, accept 2, 8, 7 B1

[Total: 6]

3 **(a)** The charges on the particles in an atom may be represented by

0 or +1 or –1.

The masses of the particles in an atom may be represented by

0 or m or 2000 m.

Using these choices, complete the table below.

particle	charge	mass
electron	–1	m
neutron		
proton		

[4]

(b) How many of each of these particles are there in a neutral atom of $^{238}_{92}U$?

number of electrons = ...

number of neutrons = ...

number of protons = ...

[3]

[Total: 7]

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3 **(a)** neutron 0 2000 m B2
proton +1 2000 m B2

(b) 92 B1
146 B1
92 no e.c.f. B1 [7]

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4 **(a)** An atom of carbon contains protons, neutrons and electrons.

Indicate where each particle is found in the atom. Place a tick in the appropriate box.

particle	in the nucleus	orbiting the nucleus
electron		
neutron		
proton		

[3]

(b) An atom of carbon contains 6 protons, 7 neutrons and 6 electrons.

(i) State the proton number of the carbon.

..... [1]

(ii) State the nucleon number of the carbon.

..... [1]

(c) Carbon has many different isotopes.

(i) Explain the meaning of the term *isotope*.

.....

.....

..... [2]

(ii) The nuclide notation for the carbon in **(b)** is $^{13}_{6}C$.

Suggest the nuclide notation for another possible isotope of carbon.

..... [1]

[Total: 8]

The nuclear atom Click for more variations

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4(a)	1st row tick under orbiting the nucleus	**B1**
	2nd row tick under in the nucleus	**B1**
	3rd row tick under in the nucleus	**B1**
4(b)(i)	6	**B1**
4(b)(ii)	13	**B1**
4(c)(i)	same proton / atomic number	**B1**
	different nucleon number / number of neutrons / mass number	**B1**
4(c)(ii)	any acceptable isotope with proton number of 6	**B1**

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5 The most abundant stable isotope of strontium is strontium-88. Its nucleon number is 88 and its proton number is 38. In nuclide notation it is written ${}^{x}_{y}Sr$.

(a) Write down

(i) the values of x and y for strontium-88, x = ...

y = ...

(ii) the number of neutrons in a nucleus of strontium-88, ...

(iii) the number of electrons in a neutral atom of strontium-88. .....

[3]

(b) Strontium-90 is a radioactive isotope produced by nuclear reactions. State how the structure of this isotope differs from that of strontium-88.

.....

.....

.....

.....

..... [2]

[Total: 5]

The nuclear atom Click for more variations

5 **(a)** **(i)** $x = 88$
AND $y = 38$ B1

(ii) 50 B1

(iii) 38 B1 [3]

(b) <u>different</u> numbers of neutrons / nucleons NOT different no of protons / electrons C1
(strontium-90 has) 52 neutrons / 90 nucleons OR 2 more neutrons / nucleons A1 [2]

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6 **(a)** Fig. 11.1 shows the paths of three α-particles moving towards a thin gold foil. Four gold nuclei are shown.

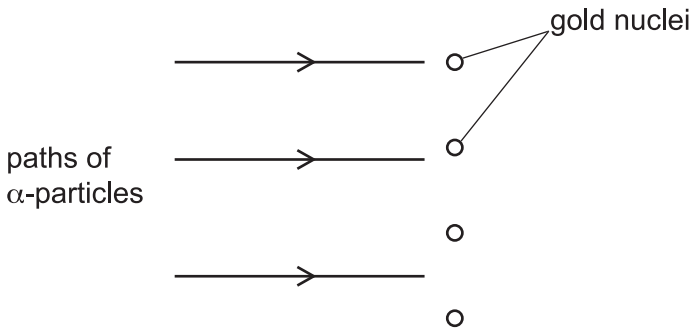


Fig. 11.1 (not to scale)

(i) On Fig. 11.1, complete the paths of the **three** α-particles. [3]

(ii) State the sign of the charge on the α-particles.

..... [1]

(b) The nuclide notation for a nucleus of gold-198 is $^{198}_{79}Au$.

State the numbers of electrons, neutrons and protons in a neutral atom of gold-198.

number of electrons = ...

number of neutrons = ...

number of protons = ...

[3]

[Total: 7]

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Reduced to 77% to fit the page (wider than A4).

6(a)(i)	top: travels to left	**B1**
	middle: deflected down AND still travels to right	**B1**
	bottom: straight on	**B1**

6(a)(ii)	plus OR positive OR +	**B1**
6(b)	79 (electrons)	**B1**
	119 (neutrons)	**B1**
	79 (protons)	**B1**

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7 In a laboratory experiment, the isotope uranium-238 is used as a source of α-particles.

(a) State

(i) one feature of uranium-238 nuclei that is the same for the nuclei of other uranium isotopes,

..... [1]

(ii) one feature of uranium-238 nuclei that is different for the nuclei of other uranium isotopes.

..... [1]

(b) Fig. 9.1 shows the α-particles from the uranium source being directed at a very thin gold foil, in a vacuum.

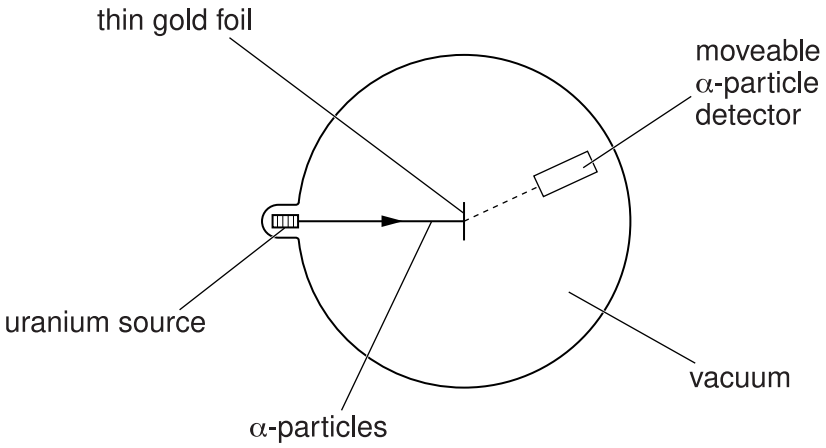


Fig. 9.1

To investigate the scattering of α-particles, a detector is moved to different positions around the very thin gold foil and measurements are recorded.

Describe the results from this scattering experiment and explain what they show about the structure of atoms.

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 6]

The nuclear atom Click for more variations

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7	**(a)**	**(i)**	same number of / 92 protons (in nucleus) (IGNORE electrons)	B1	
		(ii)	different number of neutrons	B1	
	(b)		most α-particles travel straight (through the foil)	M1	
			nucleus small / atom mostly empty space	A1	
			small number deflected (through large angles)	M1	
			most of mass in nucleus ACCEPT nucleus positive/charged	A1	[6]

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8 **(a)** A radioactive source emits α-, β- and γ-radiation.

Which of these radiations

(i) has the shortest range in air, ...

(ii) has a negative charge, ...

(iii) is not deflected in a magnetic field? .....

[2]

(b) In a famous experiment, carried out in a vacuum, a very thin sheet of gold was placed in the path of alpha particles.

It was found that a large number of the alpha particles passed through the sheet with little or no deflection from their original path. A very small number of the alpha particles were reflected back towards the source.

(i) Explain, in terms of the force acting, why the direction of motion of an alpha particle changes when it comes close to the nucleus of a gold atom.

.....

.....

..... [2]

(ii) State **two** conclusions, about the nuclei of atoms, that were made from the results of this experiment.

1. .....

.....

2. .....

.....

[2]

[Total: 6]

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8 **(a)** **(i)** alpha or α

(ii) beta or β

(iii) gamma or γ B2

Symbols must be clear
3 correct B2
2 correct B1

(b) **(i)** repulsion B1
α particle and (gold) nucleus / protons of (gold) nucleus have positive charges B1

(ii) Any two of:
Nucleus is very small (compared to size of atom) OR Most of atom is empty space

Nucleus is positive / contains protons OR Nucleus has (all) the positive charge of the atom

Nucleus is heavy OR Nucleus has most / all of the mass of the atom B2 **[6]**

Ignore neutrons

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9 Two of the isotopes of hydrogen are hydrogen-2 ($^{2}_{1}H$) and hydrogen-3 ($^{3}_{1}H$).

(a) **(i)** State **one** similarity in the composition of their nuclei.

..... [1]

(ii) Describe how a nucleus of hydrogen-3 differs from a nucleus of hydrogen-2.

.....

..... [2]

(b) In a nuclear fusion reactor, a nucleus of hydrogen-2 fuses with a nucleus of hydrogen-3 at an extremely high temperature. This fusion reaction produces an isotope of element X and releases a neutron.

(i) Explain why an extremely high temperature is needed when forcing these two nuclei together.

.....

.....

.....

..... [3]

(ii) Using nuclide notation, complete the equation for this reaction.

$$^{2}_{1}H + {}^{3}_{1}H \longrightarrow$$

[2]

[Total: 8]

The nuclear atom Click for more variations

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9(a)(i)	same number of protons / both have one proton	**B1**
9(a)(ii)	it / hydrogen-3 / $_{(1)}^{3}H$ has one more neutron	**A2**
	different number of neutrons / nucleons	C1

9(b)(i)	(high temperature produces) high (kinetic) energy / momentum / speed / ability to do large quantity of work	**B1**
	they repel each other	**B1**
	are positively charged / have like charges **or** need to come close together	**B1**
9(b)(ii)	$_{2}^{4}X$ **or** $_{2}^{4}He$ **or** $_{2}^{4}\alpha$	**B1**
	$_{0}^{1}n$ **and** no other particle	**B1**

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10 Uranium-235 ($^{235}_{92}U$) is a radioactive isotope of uranium that occurs naturally on Earth.

(a) Describe the composition and structure of a neutral atom of uranium-235.

.....

.....

.....

.....

..... [4]

(b) Another isotope of uranium is uranium-238.

Describe how an atom of uranium-238 differs from an atom of uranium-235.

.....

..... [1]

(c) In the reactor in a nuclear power station, a nucleus of uranium-235 absorbs a slow-moving neutron and then undergoes nuclear fission.

Two neutrons, a nucleus of xenon-140 ($^{140}_{54}Xe$) and a nucleus of an element represented by E are produced.

Complete the equation for this fission reaction.

$$n + {}^{235}_{92}U \rightarrow {}^{140}_{54}Xe + {}^{\cdots\cdots}_{\cdots\cdots}E + 2n$$

[2]

(d) Xenon-140 ($^{140}_{54}Xe$) is radioactive. It decays by β-emission to isotope Q.

Determine:

(i) the proton number of Q ..... [1]

(ii) the nucleon number of Q. ..... [1]

[Total: 9]

The nuclear atom Click for more variations

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10(a)	(very small) nucleus **and** surrounded by electrons (in orbit / shells)	**B1**
	92 protons **or** 92 electrons **or** number of protons = number of electrons	**B1**
	protons and neutrons in nucleus	**B1**
	143 neutrons	**B1**
10(b)	(uranium-238 has) three more neutrons (in nucleus)	**B1**
10(c)	$^{94}_{(38)}$(E)	**B1**
	$^{(94)}_{38}$(E)	**B1**
10(d)(i)	55	**B1**
10(d)(ii)	140	**B1**

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