5. Nuclear physics

5.1 The nuclear model of the atom

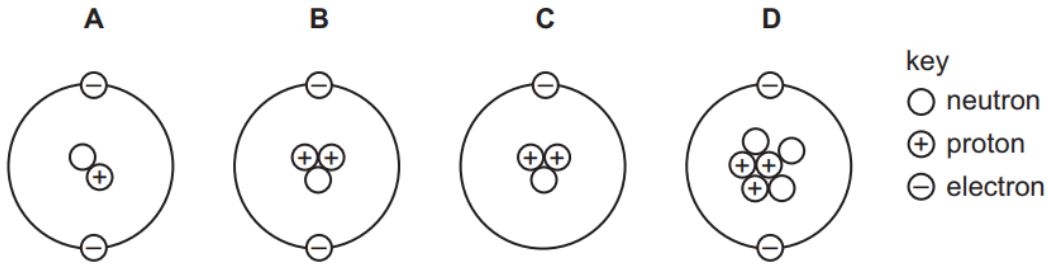
Paper 1 and 2

Question Paper

Paper 1

Questions are applicable for both core and extended candidates

1 Which diagram represents the structure of a neutral atom?



2 The half-life of the radioactive isotope caesium $^{137}_{55}Cs$ is 30 years.

Starting with 30 g of the isotope, which mass of the isotope remains after 90 years?

A 10.0 g **B** 7.50 g **C** 3.75 g **D** 1.25 g

3 A simple model of the atom consists of small particles orbiting a central nucleus.

Which row is correct?

	charge on nucleus	charge on orbiting particles
A	negative	negative
B	negative	positive
C	positive	negative
D	positive	positive

4 What is the charge on a proton and what is the charge on a neutron?

	proton	neutron
A	+1	–1
B	+1	0
C	–1	+1
D	–1	0

5 Which statement about the structure of an atom is correct?

A Negative electrons surround a neutral nucleus.

B Negative electrons surround a positive nucleus.

C Positive electrons surround a neutral nucleus.

D Positive electrons surround a negative nucleus.

6 Atom P has 6 electrons, 6 protons and 6 neutrons.

Atom Q has 6 electrons, 6 protons and 7 neutrons.

Which statement is correct?

A Atom P has atomic number 12.

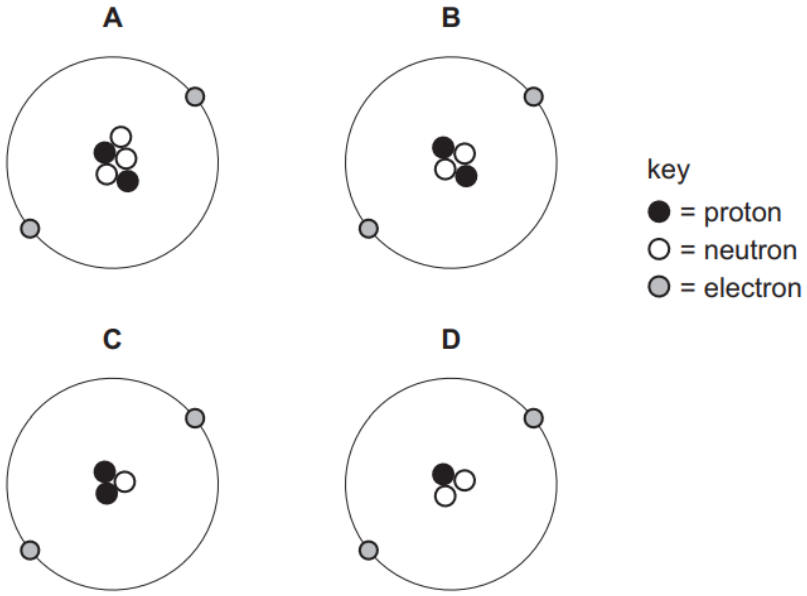
B Atom P has nucleon number 6.

C Atom Q has nucleon number 13.

D Atoms P and Q are different chemical elements.

7 The diagrams represent the protons, neutrons and electrons in different atoms and ions.

Which diagram shows a negatively charged ion?

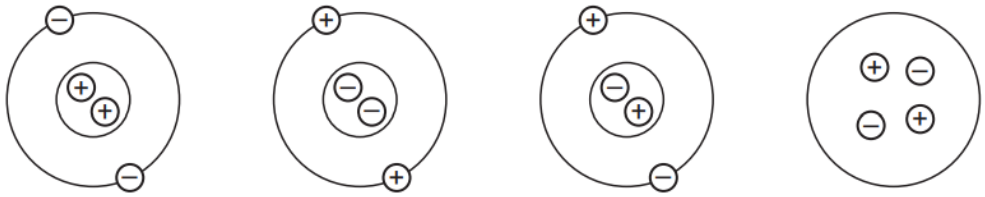


8 How are positive and negative ions formed from atoms?

	positive ion	negative ion
A	add positive charge to the nucleus	add an electron to the atom
B	add positive charge to the nucleus	remove positive charge from the nucleus
C	remove an electron from the atom	add an electron to the atom
D	remove an electron from the atom	remove positive charge from the nucleus

9 Which diagram represents the positions of the charged particles of an atom?

A **B** **C** **D**



10 The nuclide notation for the isotope lithium-7 is $^{7}_{3}\mathrm{Li}$.

How many neutrons are there in an atom of lithium-7?

A 3 **B** 4 **C** 7 **D** 10

11 A nuclide of cobalt contains 27 protons and 32 neutrons.

Which symbol represents this nuclide?

A $^{27}_{59}\mathrm{Co}$ **B** $^{32}_{27}\mathrm{Co}$ **C** $^{32}_{59}\mathrm{Co}$ **D** $^{59}_{27}\mathrm{Co}$

12 Each nucleus of nuclide X contains 10 protons and a total of 22 nucleons.

Which notation is correct for this nuclide?

A $^{22}_{10}\mathrm{X}$ **B** $^{22}_{32}\mathrm{X}$ **C** $^{12}_{10}\mathrm{X}$ **D** $^{10}_{22}\mathrm{X}$

13 A model of an atom consists of small particles orbiting a central nucleus.

Where is the positive charge in an atom?

A on the orbiting particles

B in the nucleus

C in the space between the nucleus and the orbiting particles

D spread throughout the atom

14 Which statement describes two atoms of different isotopes of an element?

A two atoms with the same nucleon number but different proton number

B two atoms with a different nucleon number but the same proton number

C two atoms with the same nucleon number and the same proton number

D two atoms with a different nucleon number and different proton number

15 The charge on a proton is e.

What is the charge on an electron and what is the charge on a neutron?

	electron	neutron
A	e	e
B	e	0
C	$-e$	$-e$
D	$-e$	0

16 The nuclide notation of the isotope strontium-90 is $^{90}_{38}\mathrm{Sr}$.

Which statement is correct?

A A nucleus of strontium-90 has 38 neutrons.

B A nucleus of strontium-90 has 52 neutrons.

C A nucleus of strontium-90 has 90 electrons.

D A nucleus of strontium-90 has 90 neutrons.

17 Which statement is correct for the nucleus of **any** atom?

A The nucleus contains electrons, neutrons and protons.

B The nucleus contains the same number of protons as neutrons.

C The nucleus has a total charge of zero.

D The nucleus is very small compared with the size of the atom.

18 The nucleus of an atom X is represented by the notation shown.

$$^{P}_{Q}X$$

How many protons and how many neutrons are in this nucleus?

	number of protons	number of neutrons
A	P	Q
B	P	Q – P
C	Q	P
D	Q	P – Q

19 The symbol represents a nucleus of zinc.

$$^{68}_{30}Zn$$

Which row gives the numbers of protons and neutrons in this nucleus?

	number of protons	number of neutrons
A	30	38
B	30	68
C	38	30
D	38	68

20 A nuclide of the element iron has the symbol shown.

$$^{56}_{26}Fe$$

What does a neutral atom of this nuclide contain?

	protons	neutrons	electrons
A	26	30	26
B	26	56	30
C	30	26	56
D	56	26	30

21 What is the nucleon number of a nuclide?

A the number of neutrons in the nucleus

B the number of protons in the nucleus

C the number of protons minus the number of neutrons in the nucleus

D the number of protons plus the number of neutrons in the nucleus

22 Which statement about the nuclei of all atoms is correct?

A They all contain electrons.

B They are all always stable.

C They all contain protons and electrons.

D They all have a positive charge.

23 The proton numbers and nucleon numbers of four nuclides are shown.

$$^{231}_{88}Ra \qquad ^{232}_{90}Th \qquad ^{238}_{92}U \qquad ^{239}_{94}Pu$$

Which statement is correct?

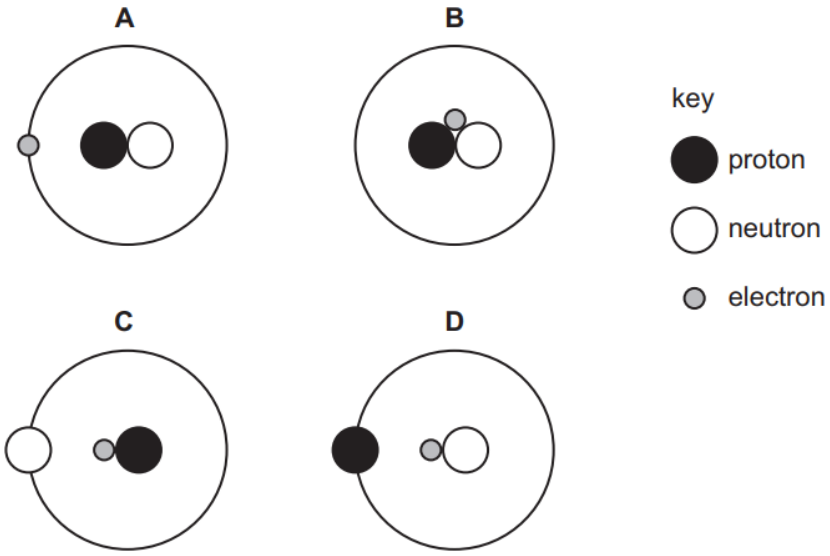
A Plutonium (Pu) contains one more proton then uranium (U).

B Thorium (Th) contains one more neutron than radium (Ra).

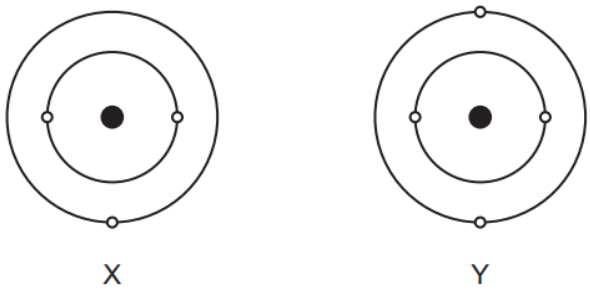
C Thorium (Th) contains one more proton than radium (Ra).

D Uranium (U) contains one more neutron than plutonium (Pu).

24 Which diagram shows a possible structure of a neutral atom?



25 The diagrams show the simple atomic structure for two neutral atoms X and Y of different elements.



Which row is correct?

	atom with more electrons	atom with a more positively charged nucleus
A	X	X
B	X	Y
C	Y	X
D	Y	Y

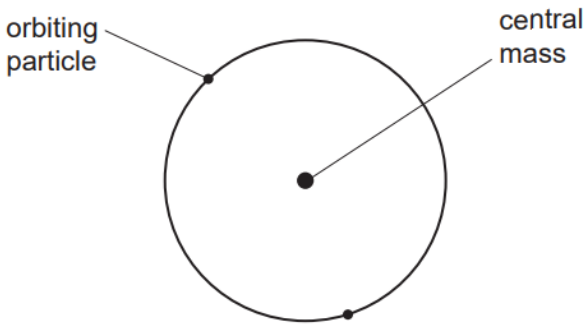
26 A nuclide of chlorine has the symbol shown.

$$^{35}_{17}Cl$$

What is the nucleon number of this nuclide of chlorine?

A 17 **B** 18 **C** 35 **D** 52

27 In the atomic model, an atom consists of a central mass, orbited by much smaller particles.



What is the name of the central mass and of the orbiting particles?

	central mass	orbiting particles
A	neutron	α-particles
B	neutron	electrons
C	nucleus	α-particles
D	nucleus	electrons

28 A neutral atom of argon-40 ($^{40}_{18}A$) and a neutral atom of potassium-39 ($^{39}_{19}K$) are compared.

Which atom has more electrons, and which atom has more protons?

	more electrons	more protons
A	argon	argon
B	argon	potassium
C	potassium	argon
D	potassium	potassium

Paper 2

Questions are applicable for both core and extended candidates unless indicated in the question

29 The notation represents the nucleus of a gold atom. **(extended only)**

$$^{197}_{79}Au$$

The relative charge on a proton is +1.

What is the relative charge on the gold nucleus?

A +79 **B** +118 **C** +197 **D** +276

30 A nucleus X has 17 protons and 18 neutrons.

Which notation is correct for this nucleus?

A $^{17}_{18}X$ **B** $^{17}_{35}X$ **C** $^{18}_{17}X$ **D** $^{35}_{17}X$

31 A magnesium ion has a double positive charge and a chloride ion has a single negative charge.

Which statement is correct?

A A chlorine atom gains an electron to form the chloride ion.

B A chlorine atom loses a proton to form the chloride ion.

C A magnesium atom loses an electron to form the magnesium ion.

D A magnesium atom gains two electrons to form the magnesium ion.

32 What happens in the process of nuclear fission? **(extended only)**

A Electrons are added to a nucleus.

B Electrons are removed from a nucleus.

C The nucleus of an atom splits.

D Two atomic nuclei join together.

33 Which row correctly states how nuclei behave during nuclear fission and during nuclear fusion?

(extended only)

	fission	fusion
A	nuclei join together	nuclei join together
B	nuclei join together	nuclei split apart
C	nuclei split apart	nuclei join together
D	nuclei split apart	nuclei split apart

34 Fission and fusion are two types of nuclear process. **(extended only)**

How does the total mass of the nuclides produced compare with the total mass of the original nuclide or nuclides in these nuclear processes?

	total mass of fission products compared to original nuclide	total mass of fusion products compared to original nuclides
A	same	same
B	more	less
C	less	more
D	less	less

35 How do the sizes of the two nuclei produced in a nuclear fission reaction compare to the size of the original nucleus?

(extended only)

A both larger than the original nucleus

B one larger and one smaller than the original nucleus

C both smaller than the original nucleus

D one smaller and one the same size as the original nucleus

36 A scientist was asked to separate the following equations into two categories: nuclear fission and nuclear fusion.

(extended only)

1 $^{239}_{94}Pu \rightarrow {}^{112}_{46}Pd + {}^{124}_{48}Cd + 3{}^{1}_{0}n$

2 $^{3}_{2}He + {}^{3}_{2}He \rightarrow {}^{4}_{2}He + {}^{1}_{1}H + {}^{1}_{1}H$

3 $^{14}_{7}N + {}^{1}_{1}H \rightarrow {}^{15}_{8}O$

4 $^{235}_{92}U \rightarrow {}^{90}_{36}Kr + {}^{143}_{56}Ba + 2{}^{1}_{0}n$

Which equations show nuclear fission?

A 1 and 2 **B** 1 and 3 **C** 1 and 4 **D** 2 and 4

37 Four students are asked to comment on the processes of nuclear fission and nuclear fusion.

Their comments are recorded in the table. **(extended only)**

Which row is correct?

	fission	fusion
A	energy is absorbed	a large unstable nucleus splits
B	a large unstable nucleus splits	energy is absorbed
C	two light nuclei join	energy is absorbed
D	energy is released	two light nuclei join

38 When a uranium-235 nucleus absorbs a neutron, it becomes unstable and undergoes fission.

The fission process produces a barium (Ba) nucleus, a krypton (Kr) nucleus and 3 neutrons.

The fission process is represented by the nuclear equation shown. **(extended only)**

$$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{144}_{56}Ba + {}^{\cdots}_{\cdots}Kr + 3{}^{1}_{0}n$$

Which symbol represents the resulting krypton nucleus?

A $^{89}_{36}Kr$ **B** $^{91}_{34}Kr$ **C** $^{91}_{35}Kr$ **D** $^{91}_{36}Kr$

39 Uranium-235 can undergo nuclear fission in many ways. **(extended only)**

Which equation correctly shows a possible fission reaction for uranium-235?

A $^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n$

B $^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{91}_{38}Sr + {}^{144}_{54}Xe + 2{}^{1}_{0}n$

C $^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{95}_{37}Rb + {}^{136}_{55}Cs + 3{}^{1}_{0}n$

D $^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{87}_{35}Br + {}^{146}_{57}La + 4{}^{1}_{0}n$

40 Nuclear fusion is a reaction that takes place in stars. **(extended only)**

Which row describes this reaction?

	action of atomic nuclei	energy
A	an atomic nucleus splits into two or more smaller nuclei	absorbed
B	an atomic nucleus splits into two or more smaller nuclei	released
C	atomic nuclei join together to form a larger nucleus	absorbed
D	atomic nuclei join together to form a larger nucleus	released

41 A thin metal foil is placed in a vacuum. α-particles are fired at the foil and most go straight through. A very small proportion of the α-particles are deflected through large angles.

What does this provide evidence for? **(extended only)**

A α-particles are very small.

B There are negative electrons in each atom.

C There is a tiny nucleus in each atom.

D There are neutrons in each atom.

42 A very important experiment increased scientists' understanding of the structure of matter.

In the experiment, particles scattered as they passed through a thin metal foil.

Which particles were used, and to which conclusion did the experiment lead? **(extended only)**

	particles	conclusion
A	alpha-particles	matter is made up of atoms
B	alpha-particles	atoms have a very small nucleus
C	beta-particles	matter is made up of atoms
D	beta-particles	atoms have a very small nucleus

43 Which particle is absorbed by a nucleus to cause nuclear fission? **(extended only)**

A a neutron

B a proton

C an α-particle

D a β-particle

44 In α-particle scattering, α-particles are incident on a thin metal foil. **(extended only)**

Which row describes results from the experiment and a conclusion that the results lead to?

	results	conclusion
A	most of the α-particles pass straight through the foil	most of the atom is empty space
B	most of the α-particles pass straight through the foil	the nucleus is very large
C	very few of the α-particles pass straight through the foil	most of the atom is empty space
D	very few of the α-particles pass straight through the foil	the nucleus is very large

45 A very important experiment improved scientists' understanding of the structure of matter.

The experiment involved α-particles being fired at a thin, gold foil. **(extended only)**

What happened?

A All the α-particles were absorbed by the nuclei of the gold atoms.

B All the α-particles were unaffected by the gold atoms.

C Some of the α-particles were attracted by the neutrons in the nuclei of the gold atoms.

D Some of the α-particles were repelled by the protons in the nuclei of the gold atoms.

46 The scattering of particles by a thin gold foil provided scientists with evidence for the nuclear atom.

Which particles were scattered by the gold nuclei in the thin foil? **(extended only)**

A α-particles

B β-particles

C neutrons

D protons

47 An isotope of hydrogen has the nuclide notation $^{2}_{1}H$. **(extended only)**

How many neutrons are in the nucleus of this isotope and what is the relative charge on the nucleus?

	number of neutrons	relative charge
A	1	+1
B	1	+2
C	2	+1
D	2	+2

48 A scientist fires alpha-particles at a very thin sheet of gold and detects the particles that pass through.

(extended only)

Which statement about the results of the scattering experiment is correct?

A Alpha-particles are attracted to the nucleus of the atoms in the metal sheet.

B Half the mass of the atom is concentrated in the nucleus.

C Most of the alpha-particles are deflected, showing that the nucleus is very dense.

D Only a small number of alpha-particles are deflected, but some of these are deflected through large angles.

49 α-particles are directed at a metal foil. **(extended only)**

Most of the particles pass through the foil with little change in direction.

A small proportion of the particles are scattered back through large angles.

What does this evidence suggest about the structure of an atom?

A It consists of a charged centre much smaller than the size of the atom and with little of the mass of the atom.

B It consists of a negative charge the size of the atom containing small positive charges scattered through it.

C It consists of a charged centre much smaller than the size of the atom but with most of the mass of the atom.

D It consists of a positive charge the size of the atom containing small negative charges scattered through it.