Combined Science

**P7**

**Atomic Structure**



Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Class \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Teacher \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Atomic structure facts**

1. The smallest part of an element that can exist.
2. Atom
3. 0.1 nm (1 x 10-10 m)
4. zero/neutral
5. An atom of the same element with different numbers of neutrons
6. An unstable nucleus changes to become more stable and gives out radiation
7. random
8. Rate at which decay occurs
9. Becquerels (Bq)
10. Number of decays recorded each second by a Geiger-Muller tube
11. The time taken for number of radioactive nuclei in a sample to halve OR time taken for count rate (or activity) from a sample to fall to half its initial value
12. proton, neutron, electron
13. protons, neutrons
14. proton +1, neutron 0, electron -1
15. proton 1, neutron 1, electron ≈ 0
16. alpha, beta and gamma
17. two protons and two neutrons
18. an electron
19. electromagnetic wave (NOT a particle)
20. radiation that is around us all the time from sources such as the air, rocks, food and drink, building materials, cosmic rays from space, medical procedures etc.
21. short - 5 cm in air
22. unlimited in air
23. medium - about 1 m
24. paper/skin
25. about 5 mm aluminium
26. several centimetres of lead
27. very high
28. medium
29. low
30. How likely it is to ionise atoms which it comes into contact with

**Fold page here**

1. Define an atom
2. All substances are made up of…?
3. The radius of an atom is …?
4. The overall charge on an atom is…
5. Define isotope
6. Define radioactive decay
7. We cannot predict when a given atom will decay, this means that radioactive deacy is ….?
8. Define activity
9. What are the units of activity?
10. Define count rate
11. Define half life
12. Name the three subatomic particles
13. Which particles are located in the nucleus?
14. What is the charge of each subatomic particle?
15. What is the mass of each subatomic particle?
16. Name the three types of radiation
17. What is an alpha particle?
18. What is a beta particle?
19. What is gamma radiation?
20. What is background radiation?
21. What is the range of alpha radiation in air?
22. What is the range of gamma radiation in air?
23. What's the range of beta radiation in air?
24. What will absorb (stop) alpha radiation?
25. What will absorb (stop) beta radiation?
26. What will absorb (stop) gamma radiation?
27. What is the ionising power of alpha radiation?
28. What is the ionising power of beta radiation?
29. What is the ionising power of gamma radiation?
30. What is meant by the ionising power of radiation?

**P7 Atomic structure Tutorial questions**

**Q1** Radioactive nuclei can emit alpha, beta or gamma radiation.

(a)  Which type of radiation is the most penetrating?

Tick **one** box.

|  |  |
| --- | --- |
| Alpha (α) |  |
| Beta (β) |  |
| Gamma (γ) |  |

**(1)**

(b)  Which type of radiation is the most ionising?

Tick **one** box.

|  |  |
| --- | --- |
| Alpha (α) |  |
| Beta (β) |  |
| Gamma (γ) |  |

**(1)**

(c)  Which type of radiation has the longest range in air?

Tick **one** box.

|  |  |
| --- | --- |
| Alpha (α) |  |
| Beta (β) |  |
| Gamma (γ) |  |

**(1)**

When radioactive isotopes in the Earth’s crust decay they release energy.

The decay causes the heating of rocks in the crust.

(d)  The diagram below shows the decay of uranium-238 (U-238) into thorium-234 (Th-234).



Complete the table below to show the number of neutrons and protons in the nuclei.

|  |  |  |
| --- | --- | --- |
| **Isotope** | **Number of neutrons** | **Number of protons** |
| uranium-238 | 146 |   |
| thorium-234 |   | 90 |

**(2)**

 **(Total 5 marks)**

**Q2.** (a) Over 100 years ago, scientists thought the atom was like a ‘plum pudding’.

 The diagram below shows the plum pudding model of the atom.



The scientists knew that an atom has negatively charged particles. They also knew that an atom has no overall charge.

What did the scientists conclude about the **charge** on the ‘pudding part’ of the atom?

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**(1)**

(b)     Two scientists named Rutherford and Marsden devised an experiment to investigate the plum pudding model of the atom. The experiment involved firing alpha particles at a thin sheet of gold. The scientists measured how many of the alpha particles were scattered.

Using the plum pudding model, the scientists predicted that only a few of the alpha particles would be scattered by more than 4°.

Over several months, more than 100 000 measurements were made.

(i)      The results from this experiment caused the plum pudding model to be replaced by a new model of the atom.

Explain why.

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**(2)**

(ii)     Suggest **one** reason why other scientists thought this experiment provided valid evidence for a new model of the atom.

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**(1)**

(c)     **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Describe the model now used for the structure of an atom.

In your answer you should:

•        give details of the individual particles that make up an atom

•        include the relative masses and relative charges of these particles.

Do **not** include a diagram in your answer.

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**(6)**

**(Total 10 marks)**

**Q3.** The diagrams below represent three atoms, **A**, **B** and **C**.



(a)     Two of the atoms are from the **same** element.

(i)      Which of **A**, **B** and **C** is an atom of a different element? \_\_\_\_\_\_\_\_\_\_\_\_\_

(ii)     Give **one** reason for your answer.

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**(2)**

(b)     Two of these atoms are isotopes of the same element.

(i)      Which **two** are isotopes of the same element? \_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_

(ii)     Explain your answer.

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**(3)**

**(Total 5 marks)**

**Q4.** The diagram shows how the thickness of aluminium foil is controlled. The thicker the aluminium foil, the more radiation it absorbs.



(a)     The designers used a beta radiation source for this control system.

(i)      Why would an alpha radiation source be unsuitable in this control system?

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**(1)**

(ii)     Why would a gamma radiation source be unsuitable in this control system?

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**(1)**

(b)     The substance used in the beta radiation source is radioactive.

(i)      Why are some atoms radioactive?

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**(1)**

(ii)     Explain why radiation is dangerous to humans.

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**(2)**

**(Total 5 marks)**

**Q5.** (a)     The graph shows how a sample of barium-143, a radioactive *isotope* with a short *half-life,* decays with time.



(i)      What is meant by the term *isotope?*

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**(1)**

(ii)     What is meant by the term *half-life*?

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**(1)**

(iii)     Use the graph to find the half-life of barium-143.

Half-life = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ seconds

**(1)**

(b)     Humans take in the radioactive isotope carbon-14 from their food. After their death, the proportion of carbon-14 in their bones can be used to tell how long it is since they died. Carbon-14 has a half-life of 5700 years.

(i)      A bone in a living human contains 80 units of carbon-14. An identical bone taken from a skeleton found in an ancient burial ground contains 5 units of carbon-14. Calculate the age of the skeleton. Show clearly how you work out your answer.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Age of skeleton = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ years

**(2)**

(ii)     Why is carbon-14 unsuitable for dating a skeleton believed to be about 150 years old?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(c)     The increased industrial use of radioactive materials is leading to increased amounts of radioactive waste. Some people suggest that radioactive liquid waste can be mixed with water and then safely dumped at sea. Do you agree with this suggestion? Explain the reason for your answer.

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 **(3)**

**(Total 9 marks)**

**Q6.** In the early part of the 20th century, scientists used the ‘plum pudding’ model to explain the structure of the atom.



Following work by Rutherford and Marsden, a new model of the atom, called the ‘nuclear’ model, was suggested.



Describe the differences between the two models of the atom.

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**(Total 4 marks)**

**Mark schemes**

**Q1.** (a)  gamma

**1**

(b)  alpha

**1**

(c)  gamma

**1**

(d)

|  |  |  |  |
| --- | --- | --- | --- |
| **isotope** | **number of neutrons** | **number of protons** |  |
| uranium-238 | 146 | **92** | **1** |
| thorium-234 | **144** | 90 | **1** |

 **[5]**

**Q2.** (a)     (an equal amount of) positive charge

*do* ***not*** *accept charge on the atom / nucleus is positive*

**1**

(b)     (i)      a (significant) number of alpha particles were scattered by more than 4°
**or**alpha particles deflected backwards

*accept (some) measurements / results were unexpected*

**1**

measurements / results could not be explained by ‘plum pudding’ model
**or**measurements / results did not support predictions

*can be explained by the nuclear model is insufficient*

*accept measurements / results did not support hypothesis*

**1**

(ii)     many / (over)100 000 measurements / results taken

*accept Rutherford(and Marsden) were respected scientists****or***

*scientists were respected*

*accept measurements / results taken over several months*

*the experiment was repeated many times is insufficient*

**1**

(c)     Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response.

|  |  |  |  |
| --- | --- | --- | --- |
| **0 marks**no relevant content | **Level 1** **(1−2 marks)**A brief description is given with some particles correctly named | **Level 2 (3−4 marks)**A description is given with all three particles named**plus either**the polarity of charge associated with thethree particles**or**the relative mass of the three particles**or**the relative mass for one particle and the relative charge for one particle given | **Level 3 (5−6 marks)**A more detailed description is given, naming the particles and polarity of charge**and either**the relative mass is given for at least two particles**or**the relative charge is given for at least two particles |
| **Examples of the points made in the response****brief description**contains protons, neutrons and electronsprotons are positiveelectrons are negativeneutrons are unchargedhas a nucleus**relative charge**proton +1electron − 1neutron 0**relative mass**proton 1neutron 1electron (about) 1 / 2000*accept protons and neutrons have the same mass**accept electrons have tiny / negligible masszero mass is neutral***more detailed description**protons and neutrons make up the nucleuselectrons orbit the nucleuselectrons are in shellsmost of the atom is empty spacenucleus occupies a very small fraction of the volume of the atomelectrons orbit at a relatively large distance from the nucleusmost of the mass of the atom is contained in the nucleusthe nucleus as a whole is positively charged total number of protons in the nucleus equals the total number of electrons orbiting it in an atom |

**6**

**[10]**

**Q3.** (a)     (i)      B

*for one mark*

**2**

(ii)     has a different number of electrons (protons)

*for one mark*

(b)     (i)      A and C

*for one mark*

**1**

(ii)     same number of protons / electrons, same nuclear charge
different number of neutrons / nuclear masses different

*for 1 mark each*

**2**

**[5]**

**Q4.** (a)     (i)      cannot penetrate aluminium

*allow can only pass through air / paper too weak is neutral*

**1**

(ii)     gamma rays not affected (by aluminium)

*allow all / most (gamma rays) to pass through*

*too strong is neutral
danger is neutral*

**1**

(b)     (i)      (nuclei) unstable

**1**

(ii)     causes harm / damage to body / cells

*allow radiation sickness*

**1**

         detail e.g., causes mutations / causes cancer / damages DNA /
damages chromosomes

*allow two effects for 2 marks*

**1**

**[5]**

**Q5.** (a)     (i)      element with equal number of protons, different number neutrons
 **or** same atomic/proton number different mass/nuclear number

**1**

(ii)     time taken for activity **or** count rate **or** number of nuclei to decrease to half

*accept parents atoms* ***or*** *radioactive isotope*

*do not accept time taken for radioactivity/substance/ material to halve*

**1**

(iii)     12 (s)

**1**

          (b)     (i)      22800 (years)

*allow 1 mark for iterative steps 80-40-20-10-5* ***or*** *statement of 4 half-lives*

**2**

(ii)     decay (of carbon 14) over 150 years is insignificant

*accept very little decay*

*accept change is too small*

**1**

(c)     either argument gains full credit

*accept any 3 valid points from for and/or against arguments*

**FOR**

* + massive dilution of waste
	+ reduces concentration (within a given volume) to insignificant levels
	+ distant from habitation

AGAINST

* pollution (of the sea/beach)
* mutation **or** harm caused to living things (animals/plants)
* effect on food chain
* long period of time necessary

**3**

 **[9]**

**Q6.** any **two** pairs from:

*to gain credit it must be clear which model is being described*

*do* ***not*** *accept simple descriptions of the diagram without comparison*

•         nuclear model mass is concentrated at the centre / nucleus (1)

*accept the nuclear model has a nucleus / the plum pudding model does not have a nucleus for* ***1*** *mark*

plum pudding model mass is evenly distributed (1)

•         nuclear model positive charge occupies only a small part of the atom (1)

plum pudding model positive charge spread throughout the atom (1)

•        nuclear model electrons orbit some distance from the centre (1)

*accept electrons in shells / orbits provided a valid comparison is made with the plum pudding model*

plum pudding electrons embedded in the (mass) of positive (charge) (1)

*do* ***not*** *accept electrons at edge of plum pudding*

•        nuclear model the atom mainly empty space (1)

plum pudding model is a ‘solid’ mass (1)

**[4]**