

1

What is the best estimate for the order of magnitude for the diameter of an atom?

A 10^{-14} m ☐

B 10^{-12} m ☐

C 10^{-11} m ☐

D 10^{-8} m ☐

(Total 1 mark)

2

A calcium ion is formed by removing two electrons from an atom of $^{40}_{20}\text{Ca}$. What is the specific charge of the calcium ion?

A 3.2×10^{-19} C kg⁻¹ ☐

B 2.9×10^{-18} C kg⁻¹ ☐

C 4.8×10^6 C kg⁻¹ ☐

D 4.8×10^7 C kg⁻¹ ☐

(Total 1 mark)

3

Which of the following nuclei has the smallest specific charge?

A ^1_1H ☐

B $^{12}_6\text{C}$ ☐

C $^{14}_6\text{C}$ ☐

D $^{235}_{92}\text{U}$ ☐

(Total 1 mark)

4

The element uranium has an isotope $^{237}_{92}\text{U}$.

- (a) Explain what is meant by an isotope.

(2)

- (b) Determine the charge in coulomb of the $^{237}_{92}\text{U}$ nucleus.

charge = _____ C

(2)

- (c) A positive ion of $^{237}_{92}\text{U}$ has a charge of $+4.80 \times 10^{-19}$ C.

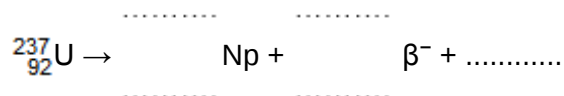
Determine the number of electrons in the ion.

number of electrons = _____

(2)

- (d) $^{237}_{92}\text{U}$ decays by β^- emission to form an isotope of neptunium (Np).

Complete the equation for this decay.



(3)

(Total 9 marks)

5

The table below contains five statements that refer to isotopes and some radium isotopes.

	$^{223}_{88}\text{Ra}$	$^{224}_{88}\text{Ra}$	$^{225}_{88}\text{Ra}$	$^{226}_{88}\text{Ra}$
Isotope with the smallest mass number	✓			
Isotope with most neutrons in nucleus				
Isotope with nucleus which has the largest specific charge				
Isotope decays by β^- decay to form $^{225}_{89}\text{Ac}$				
Isotope decays by alpha decay to form $^{220}_{86}\text{Rn}$				

- (a) Complete the table by ticking **one** box in each row to identify the appropriate isotope. The first row has been completed for you.

(4)

- (b) (i) An atom of one of the radium isotopes in the table is ionised so that it has a charge of $+3.2 \times 10^{-19} \text{ C}$.

State what happens in the process of ionising this radium atom.

(1)

- (ii) The specific charge of the ion formed is $8.57 \times 10^5 \text{ C kg}^{-1}$.

Deduce which isotope in the table has been ionised. Assume that both the mass of a proton and the mass of a neutron in the nucleus is $1.66 \times 10^{-27} \text{ kg}$.

isotope = _____

(3)

(Total 8 marks)

6

- (a) The table below contains data for four different nuclei, P, Q, R and S.

Nuclei	Number of neutrons	Nucleon number
P	5	11
Q	6	11
R	8	14
S	9	17

- (i) Which nucleus contains the fewest protons?

nucleus _____

(1)

- (ii) Which **two** nuclei are isotopes of the same element?

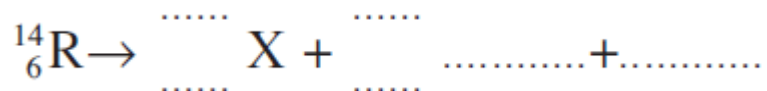
nuclei _____ and _____

(1)

- (iii) State and explain which nucleus has the smallest specific charge.

(2)

- (iv) Complete the following equation to represent β^- decay of nucleus R to form nucleus X.



(2)

- (b) (i) The strong nuclear force is responsible for keeping the protons and neutrons bound in a nucleus.

Describe how the strong nuclear force between two nucleons varies with the separation of the nucleons, quoting suitable values for separation.

(3)

- (ii) Another significant interaction acts between the protons in the nucleus of an atom. Name the interaction and name the exchange particle responsible for the interaction.

Interaction _____

Exchange particle _____

(2)

(Total 12 marks)

7

An atom of calcium, ${}_{20}^{48}\text{Ca}$, is ionised by removing two electrons.

- (i) State the number of protons, neutrons and electrons in the ion formed.

protons _____

neutrons _____

electrons _____

(3)

- (ii) Calculate the charge of the ion.

charge _____ C

(1)

(iii) Calculate the specific charge of the ion.

specific charge _____ C kg⁻¹

(2)

(Total 6 marks)

8

(a) The nucleus of a particular atom has a *nucleon number* of 14 and a *proton number* of 6.

(i) State what is meant by nucleon number and proton number.

nucleon number _____

proton number _____

(1)

(ii) Calculate the number of neutrons in the nucleus of this atom.

answer = _____

(1)

(iii) Calculate the specific charge of the nucleus.

answer = _____ C kg⁻¹

(3)

(b) The specific charge of the nucleus of another isotope of the element is $4.8 \times 10^7 \text{ Ckg}^{-1}$.

(i) State what is meant by an isotope.

(2)

(ii) Calculate the number of neutrons in this isotope.

answer = _____

(3)

(Total 10 marks)

9

(a) State what is meant by the specific charge of a nucleus and give an appropriate unit for this quantity.

unit: _____

(2)

(b) Nucleus X has the same nucleon number as nucleus Y. The specific charge of X is 1.25 times greater than that of Y.

(i) Explain, in terms of protons and neutrons, why the specific charge of X is greater than that of Y.

(2)

- (ii) Nucleus X is ${}^{10}_5\text{B}$. Deduce the number of protons and the number of neutrons in nucleus Y.

number of protons _____

number of neutrons _____

(4)

(Total 8 marks)

Mark schemes

1	C	[1]
2	C	[1]
3	D	[1]
4	(a) (isotopes have) same number of protons ✓ allow atomic mass / proton number different numbers of neutrons ✓ allow mass number / nucleon number TO where mix up atomic number and mass number (b) $92 \times 1.60 \times 10^{-19}$ ✓ correct power penalise minus sign on answer line (+) 1.47×10^{-17} (C) ✓ Allow 2 sf answer 1.5×10^{-17} (C) Pay attention to powers on answer line (c) $(4.8 \times 10^{-19} \div 1.60 \times 10^{-19} =) 3$ ✓ or $1.47 \times 10^{-17} - 4.8 \times 10^{-19} (= Q)$ (ecf) $(92 - 3 =) 89$ ✓ 95 on answer line 1 mark $(n = \frac{Q}{e} = \frac{1.47 \times 10^{-17} - 4.8 \times 10^{-19}}{1.6 \times 10^{-19}}) = 89$ (ecf) Integer value for n (d) ${}_{92}^{237}\text{U} \rightarrow {}_{93}^{237}\text{Np} + {}_{-1}^0\beta + \overline{\nu}_{(e)}$ ✓ ✓ ✓ one mark for: - both numbers correct on Np - both numbers correct on β^- - correct symbol for (electron) antineutrino	2 2 2 3

5

(a)

	$^{223}_{88}\text{Ra}$	$^{224}_{88}\text{Ra}$	$^{225}_{88}\text{Ra}$	$^{226}_{88}\text{Ra}$
Isotope with smallest mass number	(✓)			
Isotope with most neutrons in nucleus				✓
Isotope with nucleus that has highest specific charge	✓			
Isotope that decays by β^- decay to form $^{225}_{89}\text{Ac}$			✓	
Isotope that decays by alpha decay to form $^{220}_{86}\text{Rn}$		✓		

one mark for each correct row (ignore first row as already ticked)

allow cross instead of tick and ignore any crossed out ticks

if more than one tick in a row then no mark

4

(b) (i) the atom has lost two electrons✓

1

(ii) (use of specific charge = charge ÷ mass)

$$\text{mass} = 3.2 \times 10^{-19} \div 8.57 \times 10^5 = 3.734 \times 10^{-25} \text{ (kg)}$$

$$\text{mass number} = 3.734 \times 10^{-25} \div 1.66 \times 10^{-27} \checkmark (= 225)$$

hence $^{225}_{(88)}\text{Ra}$ OR 225✓✓

OR

calculate specific charge for each isotope✓

hence $^{225}_{(88)}\text{Ra}$ OR 225✓✓

ignore any reference to electrons

first mark for deduction

bald correct answer scores 2 marks

don't need radium symbol or 88

wrong answer scores zero

3

[8]

6

(a) (i) Q / boron / B ✓

1

(ii) P and R / R and P ✓

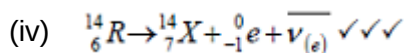
1

(iii) R ✓

6 / 14 is smallest fraction / 0.43 smallest ratio / 4.13×10^7 C / kg ✓

Cannot get second mark if not awarded first mark

2



One mark for each correct symbol on rhs

Ignore -ve sign on e.

Can have neutrino with 0,0 on answer lines

Ignore any subscript on neutrino

3

- (b) (i) repulsive below / at 0.5 fm (accept any value less or equal to 1 fm) ✓
attractive up to / at 3 fm (accept any value between 0.5 and 10 fm) ✓
short range OR becomes zero OR no effect ✓

Can get marks from labelled graph

Don't accept negligible for 3rd mark

3

- (ii) interaction: electromagnetic / em ✓

(virtual) photon/ γ ✓

2

[12]

7

- (a) (i) protons = 20 ✓
neutrons = 28 ✓
electrons = 18 ✓

3

- (ii) $2 \times 1.6 \times 10^{-19} = 3.2 \times 10^{-19}$ ✓(C)

-ve sign loses mark

1

- (iii) specific charge = $3.2 \times 10^{-19} / (48 \times; 1.67 \times 10^{-27} + 18 \times 9.11 \times 10^{-31})$ ✓

specific charge = 4.0×10^6 C kg⁻¹ ✓

Allow 1.66

Allow CE from (ii)

First mark is for mass if miss out electron mass and do not justify
lose first mark

2

[6]

8

- (a) (i) nucleon number is the number of protons and neutrons OR mass number
proton number is the number of protons OR atomic number ✓

1

- (ii) $14 - 6 = 8$ ✓

1

(iii) specific charge = $6 \times 1.6 \times 10^{-19} \checkmark / (14 \times 1.66 \times 10^{-27} \checkmark)$

specific charge = $4.1 \times 10^7 \text{ (C kg}^{-1}\text{)} \checkmark$

3

- (b) (i) isotopes are variations of an element that have same proton/atomic number $\checkmark$

but different nucleon number OR different number of neutrons $\checkmark$

2

(ii) $4.8 \times 10^7 = 6 \times 1.6 \times 10^{-19} \checkmark / (A \times 1.66 \times 10^{-27})$

$A = 6 \times 1.6 \times 10^{-19} / (4.8 \times 10^7 \times 1.66 \times 10^{-27})$

$A = 12 \checkmark$

Number of neutrons = $12 - 6 \checkmark$

3

[10]

9

- (a) the ratio of charge to mass of nucleus $\checkmark$

$\text{C kg}^{-1} \checkmark$

2

- (b) (i) number of protons and neutrons the same **or** number of neutrons less **or** mass the same $\checkmark$

but more protons therefore greater charge $\checkmark$

2

- (ii) answers add up to 10 $\checkmark$

number of protons = 4 $\checkmark$

number of neutrons = $10 - 4 = 6 \checkmark$

evidence of correct calculation $\checkmark$

eg $5q = 1.25 \times ?q$

$? = 4$

4

[8]