Mark schemes

1 (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 = 3.2×10^{-19} / (48 ×; 1.67×10^{-27} +18 × 9.11×10^{-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]

2 (a) 27 (protons) and 27 (electrons) **(1)**
32 (neutrons) **(1)**

2

(b) $^{60}_{27}Co$ **(2)**

(correct nucleon number **(1)** correct symbol and proton number **(1)**)

2

(c) (i) $^{3}_{1}H$(or $^{3}_{1}T$) **(1)**

(ii) charge / unit mass = $\dfrac{1.6 \times 10^{-19}}{3 \times 1.67 \times 10^{-27}}$ [or $\frac{1}{3}\, e / m_p$ **(1)**

= 3.19×10^{7}(C kg^{-1}) **(1)** (allow C.E. from (i))

3

[7]

3 (a)

	$^{223}_{88}Ra$	$^{224}_{88}Ra$	$^{225}_{88}Ra$	$^{226}_{88}Ra$
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 $^{225}_{89}Ac$			✓	
Isotope that decays by alpha decay to form $^{220}_{86}Rn$		✓		

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 <u>two electrons</u>✓

1

(ii) (*use of specific charge = charge ÷ mass*)
mass = $3.2 \times 10^{-19} \div 8.57 \times 10^{5} = 3.734 \times 10^{-25}$ (kg)
mass number = $3.734 \times 10^{-25} \div 1.66 \times 10^{-27}$ ✓(= 225)

hence $^{225}_{(88)}Ra$ OR 225✓✓
OR
calculate specific charge for each isotope✓

hence $^{225}_{(88)}Ra$ 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]

4 (a) 6 (protons) and 6 (electrons) **(1)**
8 (neutrons) **(1)**

2

(b) (i) ($2 \times 1.6 \times 10^{-19}$) = 3.2×10^{-19} (C) **(1)**

(ii) 14 **(1)**

(iii) $m = 14 \times 1.67 \times 10^{-27}$ (kg) **(1)**

$$\frac{Q}{M} = \left(\frac{3.2 \times 10^{-19}}{14 \times 1.67 \times 10^{-27}}\right) = 1.4 \times 10^{7} \text{ (C kg}^{-1}\text{)}$$ **(1)**

(1.37×10^{7} (C kg^{-1}))

(allow C.E for values from (i) and (ii))

4

[6]

5 (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 = $6 \times 1.6 \times 10^{-19}$✓/($14 \times 1.66 \times 10^{-27}$ ✓)

specific charge = 4.1 × 107 (C kg^{-1}) ✓

3

(b) (i) isotopes are variations of an element that have same proton/atomic number ✓

but different nucleon number OR different number of neutrons ✓

2

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

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

A = 12 ✓

Number of neutrons = 12-6 ✓

3

[10]

6 (a) number of protons = number of electrons (e.g.14) **(1)**

number of protons + number of neutrons = 28 **(1)**

2

(b) (i) nuclei with the same number of protons **(1)**
but different number of neutrons/nucleons **(1)**

(ii) (137 – 55) = 82 **(1)**

(iii) $\frac{Q}{m} = \frac{92 \times 1.60 \times 10^{-19}}{236 \times 1.67 \times 10^{-27}}$ **(1)**

$= 3.73 \times 10^{7}$ ($C\ kg^{-1}$) **(1)**

(iv) X (= 236 – 137 – 4) = 95 **(1)**

6

[8]

7 (a) the ratio of charge to mass of nucleus ✓

$C\ kg^{-1}$ ✓

2

(b) (i) number of protons and neutrons the same **or** number of neutrons less **or** mass the same ✓

but more protons therefore greater charge ✓

2

(ii) answers add up to 10 ✓

number of protons = 4 ✓

number of neutrons = 10 − 4 = 6 ✓

evidence of correct calculation ✓

eg 5q = 1.25 × ?q

? = 4

4

[8]

8 (a) 18 (protons) **(1)**
(37 – 18 gives) 19 (neutrons **(1)**

2

(b) (charge) = 2^{+} or 2^{-} **(1)**
$Q = 2 \times 1.60 \times 10^{-19} = 3.2 \times 10^{-19}$ (C) **(1)**

2

(c) (i) neutron **(1)**

(ii) electron **(1)**

2

(d) $(\%) = \dfrac{16 \times 9.11 \times 10^{-31}}{1.67 \times 10^{-27} \times 37}$ **(2)** (for correct nuclear mass and substitution)

$(= 2.36 \times 10^{-4}) = 2.36 \times 10^{-2}$ (%) **(1)**

3

[9]

Examiner reports

1 This question required a knowledge of atomic structure and specific charge and part (i) was unsurprisingly, extremely well answered.

Part (ii) caused more problems with a significant proportion of candidates either giving a charge equivalent to 20e or 18e. The calculation of specific charge has often proved to be quite discriminating with the specific charge of an ion causing candidates the most problems. On this occasion candidates performed slightly better partly due to them having been asked for the charge in part (ii) and not being penalised when carrying their answer into part (iii).

A significant proportion of candidates completely ignored the mass of the electrons and although their mass does not significantly alter the specific charge they were required to include it or to justify it being disregarded.

2 Although parts (a) and (b) followed the usual pattern of the first question on the paper, the addition of part (c) caused difficulties and full marks were few and far between. In part (a) a significant minority of candidates gave wrong answers and in part (b) almost all candidates failed to change the chemical symbol to Co, preferring to stay with Ni.

In part (c)(i) at least half the candidates gave the correct symbol for tritium but the remainder showed a variety of mistakes in the values of the superscripts and subscripts, ranging from ${}^{1}_{3}H$ to ${}^{4}_{1}H$. In part (c)(ii) only the top few percent of able candidates made a reasonable attempt at the calculation.

3 Completing the table in (a) proved to be a straightforward task for the majority of students and full marks were commonly seen. (b) proved more challenging. In the first part many students appreciated what is meant by ionization but failed to relate it directly to the situation, giving generic answers instead of stating that two electrons had left the atom.

Calculations involving specific charge have often proved discriminating in previous exams and this was certainly the case this time. Only the more able students were able to convincingly deduce the correct isotope.

4 Only the weakest candidate found difficulty with parts (a) and (b)(ii), but many more candidates failed to calculate the charge of the ion and an answer of $4 \times 1.6 \times 10^{-19}$ C was extremely common. It was surprising to see how few candidates answered (b)(iii) correctly; one source of trouble being that many incorrect constants, other than the correct mass of a nucleon, were introduced into the calculation.

5 This proved to be one of the most accessible questions on the paper with many students securing full marks. The majority of explanations of nucleon number, proton number and isotope were clear although a minority did confuse number of neutrons with number of protons in there definition of isotope. The calculations and deductions pertaining to the nucleus and one of its isotopes were in the main well set out and in many cases this helped generate correct answers. A minority, as has been the case in previous sessions, did include the mass of electrons in the specific charge calculation even though the question clearly refers to a nucleus.

6 This question yielded a good spread of marks, but each section presented some difficulties, especially for weak candidates. In general, part (a) yielded good answers. In part (b) the main difficulties encountered were converting the given information in part (iii) into correct units and in part (iv) many candidates failed to register that four neutrons were released in the splitting process.

7 Part (a) was answered well and the evidence suggests that specific charge is a topic that is now much better understood. It has often been found in previous papers that explanations which go beyond standard definitions usually produce considerable discrimination.

This was certainly the case in part (b) (i) and it was quite common for less able students to write confused and contradictory answers. A common mistake was to assume that X and Y were isotopes. Some students also thought that the question was about ions rather than nuclei.

Part (b) (ii) produced better responses although the route to a candidate's final answer was sometimes difficult to follow. A significant number of students gave answers with no working which is bad practice; especially for a question allocated four marks.

8 Part (a) usually gave a good start to the majority of candidates. In part (b) there was an even split between candidates who gave the answer as +2 and those who gave the correct answer in coulombs. The final answer was also sometimes given a negative value. The results in part (c) were, in general, correct.

In part (d) only the better candidates completed the calculation. The usual errors involved using the wrong number of electrons or nucleons or not using consistent mass units. In recent examinations it has been quite common for candidates to make errors when calculating percentages but in this question this error was not often seen.