Mark Scheme - C1.2 Basic Ideas About Atoms

1. (a) Oil is non-renewable / will run out (1)

Contribution of CO_2 to global warming (1)

Oil has other important uses (1) [2]

(Maximum 2 marks)

(b) (i) Power stations / fossil fuels used to generate the electricity needed to make H_2 (1)

Resulting in CO_2 formation (global warming) / acid rain (1)

Manufacture of car produces pollution (1) [2]

(Maximum 2 marks)

QWC Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning [1]

(ii) Disagree, no fuel is 100% safe /
petrol can burn explosively
(Accept agree if valid reason given e.g. in terms of lives being lost) [1]

(c) (i) Hydrogen since frequency is inversely proportional to wavelength / smaller wavelength [1]

(ii) Hydrogen since energy is proportional to frequency / greater frequency / E = hf [1]

(d) In Ne greater shielding of *outer* electron (1) outweighs larger nuclear charge (1) / He has greater effective nuclear charge (1) / He *outer* electron closer to nucleus (1)
- max 1 if no reference to *outer* electron [2]

(Maximum 2 marks)

(e) (i) ^{218}Po [1]

(ii) Since radon is a gas / inhaled, α particles will be given off in the lungs (which may cause cancer) [1]

Total [12]

2.

(a) M_r (PbS) = 239.1 M_r (PbO) = 223 (1)

Moles of PbS = 20,000 ÷ 239.1 = 83.65 moles (1)

Mass of PbO = 83.65 x 223 ÷1000 = 18.7 kg (1) [3]

(b) (i) Sulfur dioxide: Acid rain (1)

Carbon dioxide: Climate change / global warming / acidification of oceans (1) [2]

(ii) I. Sum of M_r of reactants = 223 + 28 = 251 (1)

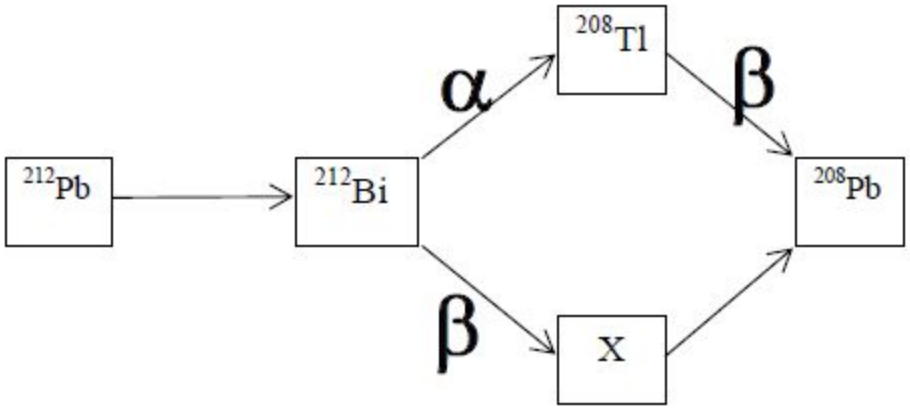
Atom economy = (207 ÷ 251) x 100 = 82.5% (1) [2]

(ii) II. Method 1 as higher atom economy means less waste / more useful product [1]

(c) (i) Symbol = Po (1) Mass number = 212 (1) [2]

(ii) All three arrows labelled correctly, as shows below, gives two marks

Any two arrows labelled correctly gives one mark [2]



(iii) γ-radiation is high energy / frequency electromagnetic waves (1)

It affects neither atomic number nor mass number / it changes neither the number of protons nor neutrons (1) [2]

(iv) 31.8 hours = 3 half lives (1)

Mass remaining after 3 half lives = 3mg (1) [2]

(d) A_r = [(206.0 x 25.48) + (207.0 x 22.12) + (208.0 x 52.40)] ÷ 100 (1)

A_r = 207.3 (1)

1 mark for correct significant figures (answer must be reasonable) [3]

Total [19]

3.

(a) Electrons within atoms occupy fixed energy levels or shells of increasing energy / nitrogen has electrons in two shells (1)
$1s^2 2s^2 2p^3$ (1)

Electrons occupy atomic orbitals within these shells /
The first shell in nitrogen has s orbitals and the second shell s and p orbitals (1)

A maximum of two electrons can occupy any orbital /
Each s orbital in nitrogen contains two electrons (1)

Each with opposite spins (1)

Orbitals of the same type are grouped together as a sub-shell / There are three p orbitals in nitrogen's p sub-shell (1)

Each orbital in a sub-shell will fill with one electron before pairing starts / In nitrogen's p sub-shell each orbital contains one electron (1)

(configuration mark + any 3 of above) [4]

QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate [1]

(b) Atomic spectrum of hydrogen is a series of lines (1)
that get closer as their frequency increases (1)
(credit possible from labelled diagram)

Lines arise from atom / electrons being excited by absorbing energy (1)
electron jumping up to a higher energy level (1)
falling back down and emitting energy (in the form of electromagnetic radiation) (1)
to the n = 2 level (1)
(any **three** points for maximum 3 marks)

Since lines are discrete energy levels must have fixed values / Since energy emitted is equal to the difference between two energy levels, ΔE is a fixed quantity or quantum (1)

[6]

(c) (i) It has greater nuclear charge (1)
but little / no extra shielding (1) [2]

(ii) In Be less shielding of outer electron (1)
outweighs smaller nuclear charge (1)

or

Be outer electron closer to nucleus (1)
Be has greater effective nuclear charge (1) [2]

(iii) I. Too much energy required to form B^{3+} ion [1]

II. $K^+(g) \rightarrow K^{2+}(g) + e^-$ [1]

III. Value of 1st and 3rd I.E. will be higher (1)
Value of 2nd I.E. will be smaller (1)
(accept large jump in I.E. value would be between 2nd and 3rd electrons for 1 mark) [2]

4.

(a) (i) 12 [1]

(ii) 14 [1]

(iii) Percentage / abundance / ratio / proportion of each isotope [1]

(b) (i) 0.125 g [1]

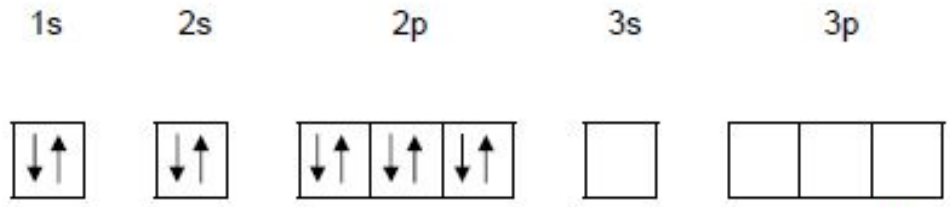
(ii) e.g. Cobalt-60 (1) in radiotherapy (1) / Carbon-14 (1) in radio carbon dating (1) / Iodine-131 (1) as a tracer in thyroid glands (1) [2]

(c) (i) Atoms are hit by an electron beam / electrons fired from an electron gun (and lose electrons) [1]

(ii) To be able to accelerate the ions (to high speed) / so that they can be deflected by a magnetic field
- no credit for 'so that *atoms* can be deflected…' [1]

(iii) They are deflected by a magnetic field / according to the m/z ratio [1]

(d)



[1]

(e) (i) $Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3$ [1]

(ii) moles $Mg(OH)_2$ = 1.75/58.32 = 0.0300 (1)

moles Mg_3N_2 = 0.0100 (1)

mass Mg_3N_2 = 0.01 x 100.9 = 1.01 g (1) [3]

- must be 3 **significant figures** to gain third mark

Total [14]

5.

(a) **2p**  [2]

2s 

(1 mark for labelling, 1 mark for arrows)

(b) (i)

N	O
25.9	74.1
14	16
1.85	4.63 (1)
1	2.5

N_2O_5 (1) [2]

(ii) $2NH_3 + 2O_2 \longrightarrow N_2O + 3H_2O$ [1]

(iii) Moles $Ca(NO_3)_2 = 5.40 \times 10^{-3}$ (1)

Moles gas $= 1.35 \times 10^{-2}$ (1)

Volume gas $= 0.324\ dm^3$ (1) [3]

(c) Moles $Ca(NO_3)_2 = 0.0256$ (1)

Moles $H_2O = 0.102$ (1)

$x = 4$ (1) [3]

Total [11]

6.

(a) same number of protons and electrons (1)

0, 1 and 2 neutrons (1) [2]

(b) (i) 3 energy levels between n = 2 and n = ∞
becoming closer together
first gap must be < that between n = 1 and n = 2 [1]

(ii) any arrow pointing upwards (1)

from n = 1 to n = ∞ (1) [2]

(c) (i) visible [1]

(ii) (not correct because) Balmer series corresponds to energy transitions involving n = 2 (1)

for ionisation energy need Lyman series / energy transitions involving n = 1 (1) [2]

(d) (i) $Q(g) \rightarrow Q^{+}(g) + e$ / accept any symbol [1]

(ii) Group 6 [1]

(iii) In T there is more shielding (1)

The outer electron is further from the nucleus (1)

The increase in shielding outweighs the increase in nuclear charge / there is less effective nuclear charge (1) [3]

Legibility of text; accuracy of spelling, punctuation and grammar; clarity of meaning QWC [1]

Total [14]

7.

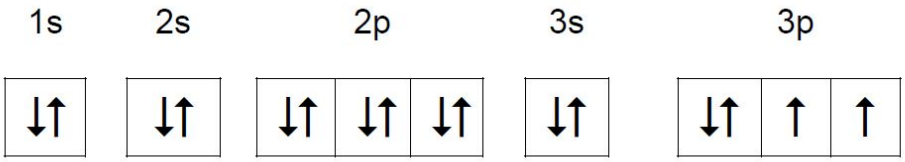
(a) C B D E A [2]

(1 mark if one mistake e.g. **A** in wrong place)

(b) Z (1)

Si is in Group 4 therefore large jump in ionisation energy would be after the fourth ionisation, not before it / **W**, **X** and **Y** have a large jump before the fourth ionisation energy so cannot be in Group 4 (1)

[2]



[1]

8.

(a) C [1]

(b) B [1]

9.

(a) $K \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ (1)
There is one outer electron and the loss of this electron gives a stable potassium ion with a full outer shell/ ion more stable than the atom (1) [2]

(b) (i) $\Delta T = 4.8\ ^{o}C$ (1)

$$\Delta H = -\frac{250 \times 4.2 \times 4.8}{0.125} = -40320\ J\ mol^{-1} / -40.3\ kJ\ mol^{-1}$$ (2) [3]

✓ for negative sign
✓ correct value with relevant units

(ii) e.g. The volume used was not precise in measurement as the readings on a beaker are only approximate (1)
The experiment was performed in a beaker and this was not insulated and heat was lost to the surroundings (1) [2]

there may be other acceptable answers here, for example based on slow dissolving

(c) (i) 0.050 [1]

(ii) $(0.050 \times 24.0) = 1.20\ (dm^3)$ [1]

(iii) % v/v $= \frac{1.20 \times 0.001 \times 100}{2}$ (1) $= 0.06$ (1) [2]

(d) An increase in the concentration of (aqueous) carbon dioxide causes the position of equilibrium to move to the right. (1)
This causes calcium carbonate to become aqueous calcium (and hydrogencarbonate) ions / dissolve (1)
weakening shells / causing difficulty in formation of shells (1) [3]

Organisation of information clearly and coherently; using specialist vocabulary where appropriate QWC [1]

Total [15]

10. (a) Electrons within atoms occupy fixed energy levels or shells of increasing energy / nitrogen has electrons in two shells (1)
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II. $K^+(g) \rightarrow K^{2+}(g) + e^-$ [1]

III. Value of 1st and 3rd I.E. will be higher (1)
Value of 2nd I.E. will be smaller (1)
(accept large jump in I.E. value would be between 2nd and 3rd electrons for 1 mark) [2]

Total [19]

11.

(a) (i) A helium (atom) nucleus / 2 protons and 2 neutrons / $^4He^{2+}$ [1]

(ii) b.....22 (1) X.....Ne (1) [2]

(iii) (4 × 2.6) = 10.4 [1]

(b) The frequency of the green line at 569 nm is HIGHER. than the frequency of the yellow-orange line at 589 nm. Another line is seen at 424 nm, this is caused by an electronic transition of HIGHER. energy than the line at 569 nm. [1]

(c) (i) Na_2CO_3 $NaHCO_3$ $2H_2O$

106 + 84 + 36 (1) → 226 [1]

(or by other appropriate method – note mark is for the working)

(ii) Atom economy = $\frac{\text{'}M_r\text{' required product} \times 100}{\text{Total 'M}_r\text{' of the reactants}}$ (1)

= $\frac{318 \times 100}{452}$ = 70.4 / 70.35 (%) (1) [2]

(iii) Carbon dioxide is produced (and released into the air) and this contributes to the greenhouse effect / increases acidity of sea (1)
It should be trapped / a use found for it. (1) [2]

(d) (i) Water is acting as a proton donor (1) and this combines with the carbonate ion / CO_3^{2-}, giving the hydrogencarbonate ion / HCO_3^- (1) [2]

(ii) The pH scale runs from 0-14 / measure of acidity / alkalinity (1)
pH <7 acid / >7 alkali (1)
acid stronger as pH value decreases / alkali stronger as pH value increases / 11.4 is strong alkali (1) [3]

Total [15]