

## Mark schemes

1

(a) 37

*These answers only.  
Allow answers in words.*

1

48

*Ignore any sum(s) shown to work out the answers.*

1

(b) (i) Electron gun / high speed/high energy electrons

*Not just electrons.*

*Not highly charged electrons.*

1

Knock out electron(s)

*Remove an electron.*

1

(ii)  $\text{Rb(g)} \rightarrow \text{Rb}^{\text{+}}(\text{g}) + \text{e}^{\text{-}}$

**OR**

$\text{Rb(g)} + \text{e}^{\text{-}} \rightarrow \text{Rb}^{\text{+}}(\text{g}) + 2\text{e}^{\text{-}}$

**OR**

$\text{Rb(g)} - \text{e}^{\text{-}} \rightarrow \text{Rb}^{\text{+}}(\text{g})$

*Ignore state symbols for electron.*

1

(c) Rb is a bigger (atom) / e further from nucleus / electron lost from a higher energy level/ More shielding in Rb / less attraction of nucleus in Rb for outer electron / more shells

*Answer should refer to Rb not Rb molecule*

*If converse stated it must be obvious it refers to Na*

*Answer should be comparative.*

1

(d) (i) s / block s / group s

*Only*

1

(ii)  $1\text{s}^2 2\text{s}^2 2\text{p}^6 3\text{s}^2 3\text{p}^6 4\text{s}^2 3\text{d}^{10} 4\text{p}^6 5\text{s}^1$

*Allow  $3\text{d}^{10}$  before  $4\text{s}^2$*

*Allow in any order.*

1

- (e)  $\frac{(85 \times 2.5) + 87 \times 1}{3.5}$   
*M1 is for top line* 1
- $= \underline{85.6}$   
*Only* 1
- OR**
- $\frac{(58 \times 5) + 87 \times 2}{7}$   
*M1<sup>85Rb</sup> 71.4% and <sup>87Rb</sup> 28.6%*  
*M2 divide by 100* 1
- $\underline{85.6}$   
*M3 = 85.6* 1
- (f) Detector  
*Mark independently*  
*Allow detection (plate).* 1
- Current / digital pulses / electrical signal related to abundance  
*Not electrical charge.* 1
- (g) Smaller  
*Chemical error if not smaller, CE = 0/3*  
*If blank mark on.* 1
- Bigger nuclear charge / more protons in Sr  
*Not bigger nucleus.* 1
- Similar/same shielding  
 QWC  
*(Outer) electron entering same shell/sub shell/orbital/same number of shells.*  
*Do not allow incorrect orbital.* 1

[16]

**2**

1

(b) **M1** ( $\text{P}_4 =$ ) **0****M2** ( $\text{H}_3\text{PO}_4 =$ ) **(+) 5***Accept Roman numeral V for M2*

2

(c)  $\text{H}_2\text{SO}_4$ **Both numbers required**

$$M_r = 2(1.00794) + 32.06550 + 4(15.99491)$$

$$= \mathbf{98.06102 \text{ or } 98.0610 \text{ or } 98.061 \text{ or } 98.06 \text{ or } 98.1}$$

*Calculations not required***and** $\text{H}_3\text{PO}_4$ 

$$M_r = 3(1.00794) + 30.97376 + 4(15.99491)$$

$$= \mathbf{97.97722 \text{ or } 97.9772 \text{ or } 97.977 \text{ or } 97.98 \text{ or } 98.0}$$

1

(d) (i) A substance that speeds up a reaction OR alters / increases the rate of a reaction **AND** is chemically unchanged at the end / not used up.**Both ideas needed***Ignore reference to activation energy or alternative route.*

1

(ii) The addition of water (**QoL**) to a molecule / compound**QoL- for the underlined words**

1

 $(\text{C}_3\text{H}_6)$ *For M1 insist on correct structure for the alcohol but credit correct equations using either  $\text{C}_3\text{H}_6$  or double bond not given.***M2** propan-2-ol

2

**[8]****3**(a)  $\text{N}^{3-} / \text{N}^{-3}$ 

1

(b) F<sup>-</sup>/ fluoride  
*Ignore fluorine/F*  
*Penalise FI* 1

(c) Li<sub>3</sub>N / NLi<sub>3</sub> 1

(d)  $\frac{81.1}{40.1}$       $\frac{18.9}{14}$   
*M1 for correct fractions* 1

(=2.02     = 1.35)  
 1.5     1     or     3 : 2  
*M2 for correct ratio* 1

Ca<sub>3</sub>N<sub>2</sub>  
*If Ca<sub>3</sub>N<sub>2</sub> shown and with no working award 3 marks*  
*If Ca<sub>3</sub>N<sub>2</sub> obtained by using atomic numbers then lose M1* 1

(e) 3 Si + 2 N<sub>2</sub> → Si<sub>3</sub>N<sub>4</sub>  
*Accept multiples* 1

[7]

4

(a)  $\frac{(82 \times 2) + (83 \times 2) + (84 \times 10) + (86 \times 3)}{17}$       $\frac{(1428)}{(17)}$   
*M1 for the top line*  
*M2 is for division by 17* 1

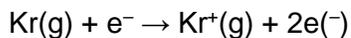
= 84.0  
*Not 84*  
*No consequential marking from M1 or M2*  
*Ignore units* 1

The A<sub>r</sub> in the Periodic table takes account of the other isotopes / different amounts of isotopes (or words to that effect regarding isotopes)  
*Award independently*  
*Comparison implied*  
*Isotope(s) alone, M4 = 0* 1

(b) (Beam of electrons from) an electron gun / high speed / high energy electrons 1

Knocks out electron(s) (to form a positive ion)

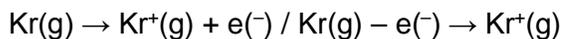
1



*State symbols must clearly be (g)*

1

**OR**



The  $^{84}\text{Kr}$  isotope

*One mark for identifying the 84 isotope*

1

Has 2 electrons knocked out / gets a 2+ charge

*One mark for the idea of losing 2 electrons (from this isotope)*

1

**[9]**

**5**

(a) (i) Different number / amount of neutrons

*Not different neutrons*

*Ignore same protons and/or electrons*

*CE incorrect statement relating to protons / electrons*

1

(ii) Same electron configuration / same number of electrons (in the outer shell)

*Ignore same no of protons*

*Ignore electrons determine chemical properties*

*CE if wrong statement relating to protons / neutrons*

1

(b) Average mass of 1 atom (of an element)

1/12 mass atom of  $^{12}\text{C}$

OR

Average/mean mass of atoms of an element

1/12 mass of one atom of  $^{12}\text{C}$

OR

(Average) mass of one mole of atoms

1/12 mass of one mole of  $^{12}\text{C}$

OR

(Weighted) average mass of all the isotopes

1/12 mass of one atom of  $^{12}\text{C}$

OR

Average mass of an atom/isotope compared to C-12  
on a scale in which an atom of C-12 has a mass of 12

*If moles and atoms mixes Max = 1*

*Mark top and bottom line independently*

*1/12 on bottom line can be represented as x 12 on top line*

*This expression = 2 marks*

2

(c) (i) 
$$\frac{(64 \times 12) + (66 \times 8) + (67 \times 1) + (68 \times 6)}{27} \quad (= 1771)$$

$$= 65.6$$

*If not 27 max 1 mark (for top line)*

*Mark is for dividing by 27 or string*

*If **evidence** of arithmetic or transcription error seen in M1 or M2  
allow consequential M3 and consequential (c)(ii)*

*65.6 = 3 marks*

3

(ii)  $^{64}\text{Zn}^+$

*M1 for identifying Zn / zinc*

*M2 is for the + sign and the 64*

*M2 is dependent on M1*

2

- (d) Size of the charge (on the ion) / different charges / different m/z  
 Allow forms 2+ ions  
 QWC  
 1
- (e) (ions hit detector and) cause current/(ions) accept  
 electrons/cause electron flow/electric pulse caused  
 bigger current = more of that isotope/current proportional to abundance  
 Implication that current depends on the number of ions  
 M2 dependent on M1  
 2

[12]

6

- (a)  $\text{Li(g)} \rightarrow \text{Li}^{\text{+}}(\text{g}) + \text{e}^{-}(\text{g})$   
 $\text{Li(g)} - \text{e}^{-}(\text{g}) \rightarrow \text{Li}^{\text{+}}(\text{g})$   
 $\text{Li(g)} + \text{e}^{-}(\text{g}) \rightarrow \text{Li}^{\text{+}}(\text{g}) + 2\text{e}^{-}$   
 One mark for balanced equation with state symbols  
 Charge and state on electron need not be shown  
 1
- (b) Increases  
 If trend wrong then CE = 0/3 for (b). If blank mark on.  
 1
- Increasing nuclear charge / increasing no of protons  
 Ignore effective with regard to nuclear charge  
 1
- Same or similar shielding / same no of shells / electron  
 (taken) from same (sub)shell / electron closer to the  
 nucleus / smaller atomic radius  
 1
- (c) Lower  
 If not lower then CE = 0/3  
 1
- Paired electrons in a (4) p orbital  
 If incorrect p orbital then M2 = 0  
 1
- (Paired electrons) repel  
 If shared pair of electrons M2 + M3 = 0  
 1

- (d) Kr is a bigger atom / has more shells / more shielding in Kr / electron removed further from nucleus/ electron removed from a higher (principal or main) energy level

*CE if molecule mentioned*

*Must be comparative answer*

*QWC*

1

- (e) 2 / two / II

1

- (f) Arsenic / As

1

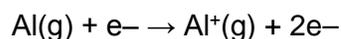
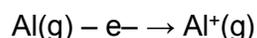
[10]

7

- (a) Cross between the Na cross and the Mg cross

1

- (b)  $\text{Al(g)} \rightarrow \text{Al}^+(\text{g}) + \text{e}^-$



*One mark for state symbols consequential on getting equation correct.*

*Electron does not have to have the – sign on it*

*Ignore (g) if put as state symbol with  $\text{e}^-$  but penalise state symbol*

*mark if other state symbols on  $\text{e}^-$*

2

- (c) 2<sup>nd</sup>/second/2/II

*Only*

1

- (d) Paired electrons in (3)p orbital

*Penalise wrong number*

*If paired electrons repel allow M2*

1

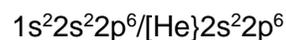
repel

1

- (e) Neon/Ne

*No consequential marking from wrong element*

1



*Allow capital s and p*

*Allow subscript numbers*

1

(f) Decreases

*CE if wrong*

1

Atomic radius increases/electron removed further from nucleus  
or nuclear charge/electron in higher energy level/Atoms  
get larger/more shells

*Accept more repulsion between more electrons for M2*

*Mark is for distance from nucleus*

*Must be comparative answers from M2 and M3*

*CE M2 and M3 if mention molecules*

*Not more sub-shells*

1

As group is descended more shielding

1

[11]

8

Mass number = number of protons + neutrons (in the nucleus/atom)

*Not in a substance or compound or element*

1

7 protons and 7 electrons

1

8 neutrons

1

[3]

9

(a) Average/mean mass of (1) atom(s) (of an element)

1

1/12 mass of one atom of  $^{12}\text{C}$

*Accept answer in words*

*Can have top line  $\times 12$  instead of bottom line  $\div 12$*

1

**OR**

(Average) mass of one mole of atoms

1/12 mass of one mole of  $^{12}\text{C}$

**OR**

(Weighted) average mass of all the isotopes

1/12 mass of one atom of  $^{12}\text{C}$

**OR**

Average mass of an atom/isotope compared to C-12  
on a scale in which an atom of C-12 has a mass of 12

$$\frac{(95.12 \times 14) + (4.88 \times 15)}{100}$$

*Allow  $95.12 + 4.88$  instead of 100*

1

= 14.05

*If not to 2 d.p. then lose last mark*

*Not 14.04*

1

(b)  $^{15}\text{N}$  is heavier/ $^{15}\text{N}$  has a bigger m/z/different m/z values

*Not different no's of neutrons*

*Not ionisation potential*

1

Electromagnet/electric field/magnet/accelerating  
potential or voltage/electric current

1

(c) No difference

1

Same no of electrons (in outer orbital/shell/sub shell)/same electron configuration

*M2 dependent on M1*

*Not just electrons determine chemical properties*

*Ignore protons*

1

[8]

10

(a) Percentage of oxygen is 36.4%

*% of oxygen stated or shown in calculation.*

1

Correct calculation of ratios (C 4.54, H 9.10, O 2.28)

*Mark is for correct method, dividing % by  $A_r$*

1

Empirical formula  $C_2H_4O$

*Allow consequential answer from wrong percentage of oxygen (max 2 marks).*

1

(b) 88

*Accept 88.0*

*Do not penalise correct answer in g.*

1

(c) Ratio MF / EF of 2 ( $88 / 44.0 = 2$ )

*If use  $132 / 44 = 3$ , molecular formula  $C_6H_{12}O_3$  scores 2 marks.*

1

Molecular formula is  $C_4H_8O_2$

*Accept consequential answers from (a) and (b)*

1

[6]

11

(a)  $2s^22p^63s^1$

*$1s^2$  can be rewritten*

*Allow  $2s^22p_x^22p_y^22p_z^23s^1$*

*Allow subscripts and capitals*

1

- (b) (i) Energy/enthalpy (needed) to remove one mole of electrons from one mole of atoms/compounds/molecules/elements 1

**OR**

Energy to form one mole of positive ions from one mole of atoms

OR

Energy/enthalpy to remove one electron from one atom

In the gaseous state (to form 1 mol of gaseous ions)

*Energy given out loses M1*

*M2 is dependent on a reasonable attempt at M1*

*Energy needed for this change*

$X(g) \rightarrow X^+(g) + e^{(-)} = 2 \text{ marks}$

*This equation alone scores one mark*

1

- (ii)  $Mg^+(g) \rightarrow Mg^{2+}(g) + e^{(-)}$   
 $Mg^+(g) + e^{(-)} \rightarrow Mg^{2+}(g) + 2e^{(-)}$   
 $Mg^+(g) - e^{(-)} \rightarrow Mg^{2+}(g)$

*Do not penalise MG*

*Not equation with X*

1

- (iii) Electron being removed from a positive ion (therefore need more energy)/electron being removed is closer to the nucleus/ $Mg^+$  smaller (than Mg)/ $Mg^+$  more positive than Mg

*Allow from a + particle/species*

*Not electron from a higher energy level/or higher sub-level*

*More protons = 0*

1

- (iv) Range from 5000 to 9000  $\text{kJ mol}^{-1}$  1

- (c) Increase

*If decrease CE = 0/3*

*If blank mark on*

1

Bigger nuclear charge (from Na to Cl)/more protons

QWC

1

electron (taken) from same (sub)shell/similar or same shielding/  
electron closer to the nucleus/smaller atomic radius

*If no shielding = 0*

*Smaller ionic radius = 0*

1

(d) Lower

*If not lower CE = 0/3*  
*If blank mark on*  
*Allow does not increase*

1

Two/pair of electrons in (3)p orbital or implied

*Not 2p*

1

repel (each other)

*M3 dependent upon a reasonable attempt at M2*

1

(e) Boron/B or oxygen/O/O<sub>2</sub>

1

**[13]**