Q16.

In 1913 Niels Bohr proposed a model of the atom with a central nucleus, made up of protons and neutrons, around which electrons moved in orbits. After further research, the model was refined when the existence of energy levels and sub-levels was recognised.

(a) Complete the following table for the particles in the nucleus.

Particle	Relative charge	Relative mass
proton		
neutron		

(2)

(b) State the block in the Periodic Table to which the element tungsten, W, belongs.

_____

(1)

(c) Isotopes of tungsten include ^{182}W and ^{186}W

(i) Deduce the number of protons in ^{182}W

_____

(1)

(ii) Deduce the number of neutrons in ^{186}W

_____

(1)

(d) In order to detect the isotopes of tungsten using a mass spectrometer, a sample containing the isotopes must be vaporised and then ionised.

(i) Give **two** reasons why the sample must be ionised.

1. _____

2. _____

(2)

(ii) State what can be adjusted in the mass spectrometer to enable ions formed by the different isotopes to be directed onto the detector.

_____

(1)

(e) State and explain the difference, if any, between the chemical properties of the isotopes ^{182}W and ^{186}W

Difference _____

Explanation _____

_____

(2)

(f) The table below gives the relative abundance of each isotope in the mass spectrum of a sample of tungsten.

m/z	182	183	184	186
Relative abundance /%	26.4	14.3	30.7	28.6

Use the data above to calculate a value for the relative atomic mass of this sample of tungsten. Give your answer to 2 decimal places.

_____

_____

_____

(2)

(Total 12 marks)

Q17.

In one model of atomic structure, the atom has a nucleus surrounded by electrons in levels and sub-levels.

(a) Define the term *atomic number*.

_____

(1)

(b) Explain why atoms of an element may have different mass numbers.

_____

(1)

(c) The table below refers to a sample of krypton.

Relative *m/z*	82	83	84	86
Relative abundance / %	12	12	50	26

(i) Name an instrument which is used to measure the relative abundance of isotopes.

_____

(ii) Define the term *relative atomic mass*.

_____

(iii) Calculate the relative atomic mass of this sample of krypton.

_____

_____

_____

(5)

(d) Give the complete electronic configuration of krypton in terms of s, p and d sub-levels.

_____

(1)

(e) In 1963, krypton was found to react with fluorine. State why this discovery was unexpected.

_____

(1)

(f) Use a suitable model of atomic structure to explain the following experimental observations.

(i) The first ionisation energy of krypton is greater than that of bromine.

_____

_____

(ii) The first ionisation energy of aluminium is less than the first ionisation energy of magnesium.

_____

_____

(4)

(Total 13 marks)

Q18.

(a) Complete the following table.

	Relative mass	Relative charge
Neutron		
Electron		

(2)

(b) An atom has twice as many protons as, and four more neutrons than, an atom of ^{9}Be. Deduce the symbol, including the mass number, of this atom.

_____

(2)

(c) Draw the shape of a molecule of $BeCl_2$ and the shape of a molecule of Cl_2O. Show any lone pairs of electrons on the central atom. Name the shape of each molecule.

$BeCl_2$ *Cl_2O*

Name of shape _____ *Name of shape* _____

(4)

(d) The equation for the reaction between magnesium hydroxide and hydrochloric acid is shown below.

$$Mg(OH)_2(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + 2H_2O(l)$$

Calculate the volume, in cm^3, of 1.00 mol dm^{-3} hydrochloric acid required to react completely with 1.00 g of magnesium hydroxide.

_____

_____

_____

_____

_____

_____

(4)

(Total 12 marks)

Q19.

(a) Complete the following table.

	Relative mass	Relative charge
Proton		
Electron		

(2)

(b) An atom of element **Q** contains the same number of neutrons as are found in an atom of ^{27}A1. An atom of **Q** also contains 14 protons.

(i) Give the number of protons in an atom of ^{27}A1.

_____

(ii) Deduce the symbol, including mass number and atomic number, for this atom of element **Q**.

_____

(3)

(c) Define the term *relative atomic mass* of an element.

_____

_____

(2)

(d) The table below gives the relative abundance of each isotope in a mass spectrum of a sample of magnesium.

m/z	24	25	26
Relative abundance (%)	73.5	10.1	16.4

Use the data above to calculate the relative atomic mass of this sample of magnesium. Give your answer to one decimal place.

_____

_____

_____

(2)

(e) State how the relative molecular mass of a covalent compound is obtained from its mass spectrum.

_____

_____

(1)

(Total 10 marks)

Q20.

(a) Complete the following table.

Particle	Relative charge	Relative mass
Proton		
Neutron		
Electron		

(3)

(b) An atom of element **Z** has two more protons and two more neutrons than an atom of $^{34}_{16}S$. Give the symbol, including mass number and atomic number, for this atom of **Z**.

_____

(2)

(c) Complete the electronic configurations for the sulphur atom, S, and the sulphide ion, S^{2-}.

S $1s^2$ _____

S^{2-} $1s^2$ _____

(2)

(d) State the block in the Periodic Table in which sulphur is placed and explain your answer.

Block _____

Explanation _____

(2)

(e) Sodium sulphide, Na_2S, is a high melting point solid which conducts electricity when molten. Carbon disulphide, CS_2, is a liquid which does not conduct electricity.

(i) Deduce the type of bonding present in Na_2S and that present in CS_2

Bonding in Na_2S _____

Bonding in CS_2 _____

(ii) By reference to all the atoms involved explain, in terms of electrons, how Na_2S is formed from its atoms.

_____

_____

(iii) Draw a diagram, including all the outer electrons, to represent the bonding present in CS_2

(iv) When heated with steam, CS_2 reacts to form hydrogen sulphide, H_2S, and carbon dioxide.
Write an equation for this reaction.

_____

(7)

(Total 16 narks)

Q21.

(a) State the relative charge and relative mass of a proton, of a neutron and of an electron.
In terms of particles, explain the relationship between two isotopes of the same element.
Explain why these isotopes have identical chemical properties.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(7)

(b) Define the term *relative atomic mass*. An element exists as a mixture of three isotopes. Explain, in detail, how the relative atomic mass of this element can be calculated from data obtained from the mass spectrum of the element.

(7)

(Total 14 marks)

Q22.

An atom in which the number of protons is greater than the number of neutrons is

A ^{234}U

B ^{6}Li

C ^{3}He

D ^{2}H

(Total 1 mark)

Mark Scheme

Q16.

(a)

Particle	Relative Charge	Relative mass
Proton	+1	1
Neutron	0	1

1

1

Need +1 for proton

(b) d block/ D block;

Or D or d

1

(c) (i) 74;

Not 74.0

1

(ii) 112;

Not 112.0

1

(d) (i) To accelerate/ make go faster;

1

To deflect/ to bend the beam;

Any order
Not just attract to negative plate

1

(ii) Electromagnet / magnet / electric field /accelerating potential or voltage;

Not electric current
Not electronic field

1

(e) None/ nothing;

If blank mark on.
If incorrect CE = 0

1

Same number of electrons (in outer orbital/shell)/ both have 74 electrons/same electron configuration;

Not just electrons determine chemical properties
Ignore protons and neutrons unless wrong statement.

1

(f) $\frac{(182 \times 26.4) + (183 \times 14.3) + (184 \times 30.7) + (186 \times 28.6)}{100}$;

If transcription error then

M1 = AE = –1 and mark
M2 consequentially

1

= 183.90; allow range from 183.90 – 184.00;

1

[12]

Q17.

(a) Number of protons in the nucleus

1

(b) They may have different numbers of neutrons

1

(c) (i) Mass spectrometer

1

(ii) $\frac{\text{Mean mass of an atom}}{\text{Mass of 1 atom of } {}^{12}C} \times 12$

2

(iii) $A_r = \frac{\text{sum of relative m/z x rel. abundance}}{\text{Total abundance}}$

1

= (82 × 12 + 83 × 12 + 84 × 50 + 86 × 26)/100 = 84.16

1

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

1

(e) Krypton was thought to be an inert gas
(or has 8 electrons in outer shell)

1

(f) (i) Krypton has more protons than bromine

1

But its outer electrons are in the same shell
(or have similar shielding)

1

(ii) Al electron is in a 3p orbital, magnesium in 3s

1

Energy of 3p is greater than 3s

1

[13]

Q18.

(penalty for sig fig error =1 mark per question)

(a) neutron: relative mass = 1 relative charge = 0
(not 'neutral')

1

electron: relative mass = 1/1800 → 0/negligible *or*

5.56 × 10–4 → 0 relative charge = –1

1

(b) $^{17}O/O^{17}$ mass number (*Do not accept 17.0*)

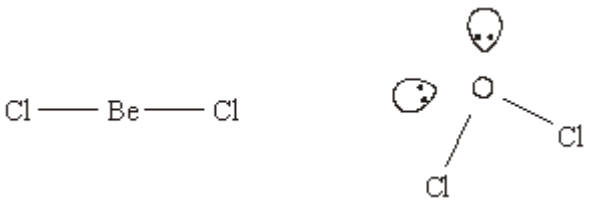
1

oxygen symbol 'O'

(if 'oxygen' + — 'mass number = 17'(1))
(if 'oxygen'+ — 'mass number = 17'(0))
(if at N⁰ given but ≠ 8, treat as 'con' for M2)
(if lp on Be, diagram = 0)
(ignore bond angles)
(not dot and cross diagrams)

1

(c)



2

QoL Linear **(1)** bent / V-shaped / angular **(1)**

(mark name and shape independently)
(accept (distorted) tetrahedral)
(if balls instead of symbols, lose M1 – can award M2)
(penalise missing 'Cl' once only)
(not 'non-linear')

2

(d) M_r $(Mg(NO_3)_2$ = 58(.3) *(if At N⁰ used, lose M1 and M2)*

1

moles $Mg(OH)_2$ = 0.0172 (conseq on wrong M2) (answer to 3+ s.f.)

1

moles HCl = 2 × 0.0172 = 0.0344 *or* 0.0343 (mol) *(process mark)*

1

vol HCl = $\frac{0.0343 \times 1000}{1}$ = 34.3 – 34.5 (cm^3) *(unless wrong unit)*

*(if candidate **used** 0.017 or 0.0171 lose M2)*
(just answer with no working, if in range = (4).
if, say, 34 then =(2))
(if not 2:1 ratio, lose M3 and M4)
(if work on HCl, CE = 0/4)

1

[12]

Q19.

(a) Proton mass = 1 charge = +1
Electron mass ≤ 1/1800 Or ≤ 5.6×10^{-4} charge = –1
(Do not accept +1 for proton mass or 'g' units)

2

(b) (i) 13

1

(ii) Si

1

Mass number = 28 **and** atomic number = 14
(Do not accept 28.1 or 28.0 or 'Silicon')

5

(c) Mean (average) mass of an atom / all the isotopes
1/12th mass of atom of ^{12}C
Or Mass of 1 mole of atoms of an element **(1)**
1/12th mass of 1 mole of ^{12}C **(1)**
Or Average mass of an atom / all the isotopes **(1)**
relative to the mass of a ^{12}C atom taken as exactly 12 / 12.000 **(1)**
(Penalise 'weight' once only) (Ignore 'average' mass of ^{12}C)
(Do not allow 'mass of average atom')

2

(d) $A_r = (24 \times 0.735) + (25 \times 0.101) + (26 \times 0.164)$ 1 = 24.4 1
(mark M2 conseq on transcription error or incorrect addition of %)

(e) M_r = highest m/z value 1
(NOT 'highest/largest/right-hand' peak)

3

[10]

Q20.

(a)

Particle	Relative charge	Relative mass	
Proton	+1 **or** 1+	1	**(1)**
Neutron	0 **or** no charge/neutral/zero	1 (not – 1)	**(1)**
Electron	–1 or 1–	1/1800 to 1/2000	**(1)**

or negligible
or zero
or 5.0×10^{-4} to 5.6×10^{-4}
if 'g' in mass column - wrong

penalise once

3

(b) $^{38}_{18}Ar$ **(1)(1)**

Allow numbers before or after Ar

2

(c) *S*: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$ **(1)**

Allow upper case letters

S^{2-}: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ **(1)**

If use subscript penalise once

2

(d) *Block*: p **(1)**
Explanation: Highest energy or outer orbital is (3) p

OR outer electron, valency electron in (3) p
NOT 2p etc.

2

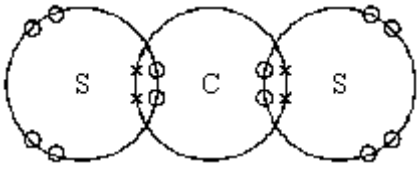
(e) (i) *Bonding in Na_2S*: ionic **(1)**
Bonding in CS_2: covalent **(1)**

ignore other words such as dative / polar / co-ordinate

(ii) Clear indication of electron transfer from Na to S **(1)**
1 e^- from each (of 2) Na atoms or 2 e^- from 2 Na atoms **(1)**

QoL correct English

(iii)



Correct covalent bonds **(1)**
All correct including lone pairs **(1)**

Allow all •s or all ×s
M2 tied to M1
NOT separate e^-s in S•- 2 l p

(iv) $CS_2 + 2H_2O \rightarrow CO_2 + 2H_2S$ **(1)**

Ignore state symbols even if wrong

7

[16]

Q21.

(a) Proton: mass 1, charge + 1 **(1)**
Neutron: mass 1, charge 0 **(1)**
Electron mass 1/1840, charge -1 **(1)**

Allow mass = 0, or negligible, or 1/1800 to 1/2000

Isotopes have the same number of protons **(1)**
OR atomic number

different number of neutrons **(1)**

Isotopes have the same electronic configuration **(1)**
OR same number of electrons

Chemical properties depend on electrons **(1)**

7

(b) $\frac{\text{average (1) mass of an atom/isotopes}}{\text{mass of 1 atom of } {}^{12}\text{C}} \times 12$ **(1)**

OR $\frac{\text{mass of 1 mol of atoms}}{\text{mass of 1 atom of } {}^{12}C} \times 12$ *or in words*

Spectrum gives (relative) abundance **(1)**
OR % or amount

And *m/z* **(1)**
Multiply *m/z* by relative abundance for each isotope **(1)**
Allow instead of m/z mass no, A_r or actual value from example

Sum these values **(1)**
Divide by the sum of the relative abundances **(1)**
only award this mark if previous 2 given
Max 2 if e.g. has only 2 isotopes

7

[14]

Q22.

C

[1]