AQA A-LEVEL CHEMISTRY · 7405

CHEMISTRY



MARK SCHEME

3.2.1 PERIODICITY

SCORE	PERCENTAGE
/90	%

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Q1.

C

[1]

Q2.

D

[1]

Q3.

C

[1]

Q4.

(a) (i) d (block) **OR** D (block)

Ignore transition metals / series.

Do not allow any numbers in the answer.

1

(ii) Contains positive (metal) ions or protons or nuclei and <u>delocalised / mobile / free / sea of</u> electrons

Ignore atoms.

1

<u>Strong attraction</u> between them or <u>strong metallic</u> bonds

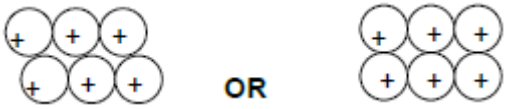
Allow 'needs a lot of energy to break / overcome' instead of 'strong'.

If strong attraction between incorrect particles, then CE = 0 / 2.

If molecules / intermolecular forces / covalent bonding / ionic bonding mentioned then CE=0.

1

(iii)



M1 is for regular arrangement of atoms / ions (min 6 metal particles).

M2 for + sign in each metal atom / ion.

Allow 2^+ sign.

2

(iv) <u>Layers / planes / sheets of atoms or ions</u> can slide over one another

QoL.

1

(b) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ (4s^0)$

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Only.

1

(ii) $NiCl_2.6H_2O$ + **6** $SOCl_2$ ⟶ $NiCl_2$ + **6** SO_2 + **12** HCl

Allow multiples.

1

NaOH / NH_3 / $CaCO_3$ / CaO

Allow any name or formula of alkali or base.

Allow water.

1

[9]

Q5.

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

OR

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

OR

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

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

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

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Allow in any order.

1

(e) $\frac{(85 \times 2.5) + 87 \times 1}{3.5}$

M1 is for top line

1

1

$= \underline{85.6}$

Only

1

OR

$\underline{(58 \times 5) + 87 \times 2}$
7

M1 ^{85}Rb 71.4% and ^{87}Rb 28.6%

M2 divide by 100

1

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]

Q6.

(a) Outer electrons are in p orbitals

1

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(b) decreases

1

Number of protons increases

1

Attracting outer electrons in the same shell (or similar shielding)

1

(c) Sulfur molecules (S_8) are larger than phosphorus (P_4)

1

Therefore van der Waals' forces between molecules are stronger

1

Therefore more energy needed to loosen forces between molecules

1

(d) Argon particles are single atoms with electrons closer to nucleus

1

Cannot easily be polarised (or electron cloud not easily distorted)

1

[9]

Q7.

(a) enthalpy/energy change/required when an electron is removed/ knocked out / displaced/ to form a uni-positive ion

(ignore 'minimum' energy)

1

from a gaseous atom

(could get M2 from a correct equation here)
(accept 'Enthalpy/energy change for the process...' followed by an appropriate equation, for both marks)
(accept molar definitions)

1

(b) $1s^2\ 2s^2 2p^6$

(accept capitals and subscripts)

1

(c) 's' block

(not a specific 's' orbital – e.g. 2s)

1

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

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

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

1

(e) Mg^{2+} ion smaller than Ne atom / Mg^{2+} e^- closer to nucleus

(Not 'atomic' radius fo Mg^{2+})

1

Mg^{2+} has more protons than Ne / higher nuclear charge or

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e^- is removed from a charged Mg^{2+} ion / neutral neon atom

(accept converse arguments)

*(If used 'It' or Mg/magnesium/Mg^{3+} etc. & 2 correct reasons, allow **(1)**)*

1

(f) (i) trend: increases

(if 'decreases', CE = 0/3)

1

Expl^n: more protons / increased proton number / increased nuclear charge

(NOT increased atomic number)

1

same shell / same shielding / smaller size

1

(ii) QoL reference to the e– pair in the 3p sub-level

(penalise if wrong shell, e.g. '2p', quoted)

1

repulsion between the e^- in this e^- pair

(if not stated, 'e^- pair' must be clearly implied)

(mark M4 and M5 separately)

1

[12]

Q8.

(a) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ **(1)**

Allow subscripted electron numbers

(ii) p (block) **(1)**

Allow upper or lower case 's' and 'p' in (a)(i) and (a)(ii)

2

(b) Lattice of metal / +ve ions/ cations / atoms **(1)**

Not +ve nuclei/centres

Accept regular array/close packed/tightly packed/uniformly arranged

(Surrounded by) delocalised electrons **(1)**

Note: Description as a 'giant ionic lattice' = CE

2

(c) Greater nuclear or ionic charge or more protons **(1)**

Smaller atoms / ions **(1)**

Accept greater charge density for either M1 or M2

More delocalised electrons / e^- in sea of e^- / free e^- **(1)**

Stronger attraction between ions and delocalised / free electrons etc. **(1)**

Max 3

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Note: 'intermolecular attraction/ forces' or covalent molecules = CE

Accept stronger 'electrostatic attraction' if phrase prescribed elsewhere
Ignore references to m/z values
If Mg or Na compared to Al, rather than to each other, then: ***Max 2***
*Treat description that is effectively one for Ionisation Energy as a '**contradiction**'*

3

(d) (Delocalised) electrons **(1)**

Move / flow in a given direction (idea of moving non-randomly)
or under the influence applied pd *QoL mark* **(1)**

Allow 'flow through metal'

Not: 'Carry the charge'; 'along the layers'; 'move through the metal'

2

[9]

Q9.

(a)

Particle	Relative charge	Relative mass	
Proton	+1 **or** 1+	1	**(1)**
Neutron	0 **or** no charge/neutral/zero	1 (<u>not</u> – 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

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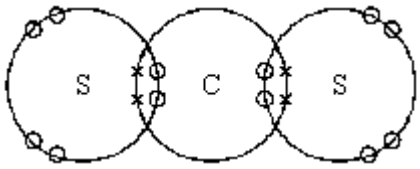
OR outer electron, valency electron in (3) p
NOT 2p etc.

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)**
<u>All correct</u> including <u>lone pairs</u> **(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]

Q10.

(a) Elements in the p block have their outer electron(s) in
p orbital(s) or levels or sub-shells **(1)**
example of element **(1)**
correct electronic configuration **(1)**

3

(b) Pattern in the change in the properties of a row of elements **(1)**
OR Trend in the properties of elements across a period

Repeated in the next row **(1)**
OR element underneath (or in same group) has similar properties

atomic radius
decreases across the row **(1)**
CE if trend is wrong

number of protons increases **(1)** (or nuclear charge increases)
<u>more attraction for electrons</u> in the same shell **(1)**

electronegativity
increases across the row **(1)**
number of protons increases **(1)** (or nuclear charge)
atomic radius decreases **(1)** (or shielding remains the same or electrons

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in the same shell) more attraction for <u>bonding</u> or <u>shared</u> electrons **(1)**

conductivity
decreases row **(1)**

OR significant drop from Al to Si

Na–Al metals **(1)**

OR metallic bonding or description of metallic bonding

Two of Si - Ar non metals **(1)**

OR molecular or covalent

EITHER electrons free to move (or delocalised) in metals
OR electrons unable to move in non-metals **(1)**

13

[16]

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Q3.

Usually well answered.

Q4.

This question was generally quite well answered. In part (a)(i), most students knew the correct block in the Periodic Table although some seemed to think that the name 'Transition Metals' was enough to identify the d block. In part (a)(ii), the biggest issue was the omission of 'positive' when describing ions and 'delocalised' when describing the electrons involved in the bonding. The diagrams in part (a)(iii) generally scored highly but some were untidy and failed to show a regular arrangement of ions. Surprisingly, many students did not refer to layers of atoms / ions sliding in part (a)(iv) and therefore did not score the mark. Answers to part (b)(i) were disappointing and showed that students could not write the electron configuration of ions in the d block. Balancing the equation proved difficult but a good number of students did this well and many students could suggest a suitable substance in part (b)(ii).

Q5.

Part (a) was done very well. In part (b)(i), many students stated that a positive ion was formed but failed to say how. The equation in part (b)(ii) was well done with only a few omitting the state symbols. In part (c), a number of students failed to score the mark since they referred to a rubidium molecule, showing a lack of understanding of the metals given. In part (d)(ii) there were many students who filled the 4d rather than the 5s orbitals and some gave an abbreviated electron structure even though the question asked for the full electron structure. Many students found part (e) difficult although it was pleasing to see some gain full marks. Part (f) was not well understood with many students confusing charge and current. The answers to part (g) were generally good although a few students did not give complete explanations and lost the last mark.

Q7.

Candidates tended to score a little better on this question than on question 3 but, overall, the question was not well answered. Part (a) was generally well done, although incomplete answers were quite common. The most common error was to omit reference to *gaseous atoms*.

Parts (b) and (c) were often well answered; however, in part (d) incorrect ionic charges and missing or incorrect state symbols were quite often seen.

Part (e) was poorly done. Many candidates referred to difference in the number of electron shells present in the two species despite being told in the question that they had the same number of electrons. Some candidates attributed the difference to a special stability enjoyed by neon as a consequence of it having a full outer electron shell. Clearly, the majority of candidates failed to appreciate the significance of the two species having the same number of electrons. Many answers referred to "It', magnesium or Mg, rather than correctly identifying the species being discussed.

In part (f), candidates are asked to demonstrate their understanding of a trend required in the specification. While part (f)(i) was often competently dealt with, answers in part (f)(ii) frequently lacked sufficient specific detail to be awarded credit. Often, candidates failed to identify the electron pair from which from which the first electron would be removed, or to

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explain the relatively low first ionisation energy of sulphur in terms of repulsion between the electrons in this electron pair. Vague phrases such as '*electron pairs repel*', or a reference to a more stable half-filled shell being formed, earned no credit.

Q8.

Some good responses were seen but overall this question was not well answered however most candidates managed to earn some marks. Part (a) was generally satisfactorily answered with occasional errors in the electron configuration, and most candidates correctly assigned aluminium to the p block of the Periodic Table. In part (b), references to delocalised electrons were frequently seen, however mention of the existence of a close-packed lattice of positive ions was much less common. Some good answers were seen in part (c), although many responses were related to differences in ionisation energy rather than to differences in melting point. There was also much confusion over the type of attractive force present, with frequent references to 'ionic bonding', 'intermolecular forces', and to 'magnesium having a full s subshell'.

Only rarely was the higher melting point of magnesium attributed to a greater attraction between the ionic lattice and the delocalised electrons that resulted from its higher ionic charge and increased number/concentration of delocalised electrons. In part (d), most candidates made mention of electrons but very few made reference to an electrical current being a flow of electrons through a metal. The incorrect idea of passing the charge from one electron to another was very common, as were vague references to electrons being free to move in the metal.

Q9.

Many candidates answered this question quite well but full marks were not that common. Most candidates correctly completed the table in part (a) but it was not unusual for either the signs or the values of the relative charges to be omitted. In a few instances, the values of the electron and the neutron were transposed. Success in part (b) was far from universal. Errors such as 39.9 and 36 for the mass number were quite common, as was the use of Z to represent the element. Part (c) was, in the main, successfully completed but the odd d level was seen, as were configurations for the S^{2-} ion showing $3p^2$ rather than $3p^6$ electrons, or even a $2p^8$ arrangement. While part (d) was also generally well done, some candidates were found to be unfamiliar with this part of the specification and the suggestion that the element was found in block 6, because it contained 6 outer electrons, was not uncommon. Some candidates incorrectly referred to the p-block or p-shell, rather than using the correct terms sub-level or sub-shell. In part (e), a surprising number of candidates identified incorrectly the bonding in Na_2S as being covalent or metallic, and the bonding in CS_2 as being ionic, molecular or dative. For those candidates who did recognise the ionic nature of the bonding in Na_2S, their descriptions were often vague and they did not express clearly the transfer of electrons which takes place, and the numbers of electrons involved. Many answers could have equally well fitted the description for the formation of a covalent bond. The diagram of the bonding in CS_2 was frequently flawed, with spare electrons being placed around carbon and extra lone pairs on the sulphur atoms. Some candidates showed a single bond between the sulphur and carbon atoms, whilst others only included a single sulphur atom. The equation was almost invariably correct; although, in a few cases, the equation was not balanced.

Q10.

Marks awarded for this question were not as high as for question 5. There was some evidence that candidates were short of time, particularly those who wrote irrelevant information about the operation of the mass spectrometer in question 5. In part (a) the example of a p-block element and its electronic configuration were more often correct than was an explanation of why elements are classified as p-block. The meaning of the term

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periodicity was not understood well in part (b). Many candidates considered that periodicity referred to trends down a Group. The remainder of part (b) discriminated effectively between good and weak candidates. The latter sometimes stated trends in the wrong direction and gave only partial explanations.