F321: Atoms, Bonds and Groups
Periodicity – Mark Scheme

1. Xe has a bigger atomic radius **OR** Xe has more shells ✓

__ALLOW__ Xe has more energy levels
__ALLOW__ Xe has electrons in higher energy level
__ALLOW__ Xe has electrons further from nucleus
__IGNORE__ Xe has more orbitals __OR__ more sub-shells
__DO NOT ALLOW__ 'different shell' or 'new shell'

Xe has **more** shielding ✓

__ALLOW More__ screening
There must be a clear comparison ie __more__ shielding __OR__ __increased__ shielding.
i.e. __DO NOT ALLOW__ Xe 'has shielding'
__ALLOW__ Xe has __more__ electron repulsion from inner shells

The nuclear attraction decreases
OR Outermost electrons of Xe experience less attraction (to nucleus)
OR Increased shielding / distance outweighs the increased nuclear charge ✓
ORA throughout

__ALLOW__ Xe has less nuclear pull
__IGNORE__ Xe has less effective nuclear charge
__DO NOT ALLOW__ nuclear charge for nuclear attraction

[3]

2. (i) Potassium **AND** argon ✓

__ALLOW__ K and Ar

1

(ii) They are arranged in increasing atomic number
OR
Neither would show properties **OR** trends of rest of group
OR
Neither would show properties **OR** trends of rest of period
OR
They are arranged by electron configuration ✓

__ALLOW__ any correct property difference
e.g. This would place a reactive metal in the same group as noble gases

__ALLOW__ they do not fit in with the rest of the group

1

[2]

3. (a) (i) Magnesium ions have a greater charge✓

Magnesium has more
(delocalised **OR** outer) **electrons**✓

Magnesium has greater attraction between **ions** and
electrons OR has stronger **metallic** bonds ✓

USE annotations with ticks, crosses, ecf, etc for this part.

ALLOW REVERSE ARGUMENT
e.g. sodium ions have a smaller charge
ALLOW *Mg^{2+} / Mg ion / Na ion / Na^{+} ion*
ALLOW *'charge density' as alternative to 'charge'*

ALLOW REVERSE ARGUMENT
e.g. sodium has fewer electrons

ALLOW REVERSE ARGUMENT
*e.g. sodium has less attractions between **ions** and **electrons***
OR *has weaker **metallic** bonds* ✓

3

(ii) Cl_2 **OR** S_8 has intermolecular **OR** van der Waals' forces ✓

S_8 has stronger intermolecular forces **OR** van der Waals' forces than Cl_2

OR
S_8 has more electrons ✓

ALLOW REVERSE ARGUMENT *ie Cl_2 has weaker intermolecular forces **OR** van der Waals' forces*
DO NOT ALLOW *comparison involving covalent bonds*

ALLOW REVERSE ARGUMENT
Cl_2 has fewer electrons

2

(b) nuclear charge increases/ protons increase ✓

electrons added to the same shell
OR
screening **OR** shielding remains the same ✓

greater attraction **OR** greater pull ✓

USE annotations with ticks, crosses, ecf, etc for this part.

Nuclear OR proton(s) OR nucleus spelt correctly ONCE

IGNORE *'atomic number increases'*
IGNORE *'nucleus gets bigger'*
'charge increases' is not sufficient
ALLOW *'effective nuclear charge increases'* ***OR*** *'shielded nuclear charge increases'*

IGNORE *reference to atomic radius staying the same*

ALLOW *shielding is similar*
DO NOT ALLOW *extra shielding*

A comparison ***must*** *be included:*
*i.e. '****greater*** *pull', '****more*** *pull', 'held* ***more*** *tightly';*

3

[8]

4. (i) outer electrons closer to nucleus **OR** radii decreases ✓

nuclear charge increases
OR protons increase ✓

electrons added to the same shell
OR
screening **OR** shielding remains the same ✓

IGNORE *'atomic number increases'*
IGNORE *'nucleus gets bigger'*
'charge increases' is not sufficient
ALLOW *'effective nuclear charge increases'* ***OR*** *'shielded nuclear charge increases'*

ALLOW *shielding is similar*

3

(ii) atomic radii increase **OR**
there are more shells ✓

there is **more** shielding **OR more** screening ✓

the nuclear attraction decreases
OR
Increased shielding / distance outweigh the increased
nuclear charge ✓

ALLOW *electrons in higher energy level*
ALLOW *electrons are further from the nucleus*
DO NOT ALLOW *more orbitals* ***OR*** *more sub-shells*
DO NOT ALLOW *different shell or new shell*

*There must be a clear comparison: e.g. '****more*** *shielding', '****increased*** *shielding'. i.e.* ***DO NOT ALLOW*** *just 'shielding'.*
ALLOW *'****more*** *electron repulsion from inner shells'*

Nuclear OR proton(s) OR nucleus spelt correctly ONCE
ALLOW *'nuclear pull'*
IGNORE *any reference to 'effective nuclear charge'*

3

[6]

5. (i) S **(1)** 1

(ii) A*l* **(1)** 1

(iii) B **(1)** 1

(iv) Ca **(1)** 1

(v) K **(1)** 1

(vi) K **(1)** 1

[6]

indent3;mark;Default;header;**TOCI;**Answer;Part

lines;question(a)(i);indent2;**indent1(a);BoxL;Bottom;heading**

1;heading 2;heading 3;heading 4;heading 5;*heading 6;heading*

7;♒♏♋♎♓■♑ ♁🖴heading

9;ex;ex2;graph;Hyperlink;right;Box;BoxR;annotation reference; ✓☐☐☐☐☐ ***6.*** (i)atomic radii decrease /s

number of protons in the nucleus increases **(1)**
nuclear attraction increases **(1)** 3

(ii) $Na^{2+}(g) \rightarrow Na^{3+}(g) + e^-$: equation and state symbols **(1)** 1

(iii) large jump (in energy) between the 4th and 5th ionisation energies **(1)**
four electrons in outer shell so element is Si **(1)** 2

[6]

7. atomic radii of Rb > atomic radii of elements above/
Rb has electrons in shell further from nucleus /
Rb has more shells ✓

Rb has **more** shielding ✓ (***'more'*** *is essential*)

(increased) nuclear charge is outweighed /
despite increased nuclear charge …..by at least one of the factors above/
less attraction/ held less tightly ✓

[3]

8. (i) They have different numbers of protons/
Ba has one more proton/Ba has 56 p^+; Cs has 55 p^+ ✓ 1
(ignore electrons: any mention of 'neutrons' is wrong)

(ii) s ✓ 1

(iii) Cs to Ba: nuclear charge increases/more protons ✓
electrons are in: the same shell/sub-shell/orbital /similar shielding/same shielding ✓ 3
attraction increases/pull increases ✓ …….ORA

(iv) smaller ✓ 2
shell has been lost/less shielding/less electron repulsion/proton : electron ratio larger ✓
mark separately

[7]

9. (a) Energy change when **each atom in 1 mole**✓
of gaseous **atoms**✓
loses an electron ✓ (to form 1 mole of gaseous 1+ ions). 3

(b) From Li → N, ionisation energy increases✓
number of protons/nuclear charge increases✓
nuclear attraction increases / shell drawn in by increased nuclear charge/ atomic radius decreases✓
across period, electrons added to same shell✓
Not same subshell

From Be → B, ionisation energy decreases✓
for B, electron is removed from a p sub-shell/p orbital/different sub-shell✓
which has a higher energy✓ 7
*watch for distinction between nuclear **attraction** and nuclear **charge** in candidates' scripts.*
Also watch for confusion between shell and subshell.

Al✓
Sharp rise in successive ionisation energy between 3rd and 4th IE✓
marking a change to a new or different shell / there are 3 electrons in the outer shell✓ 3
*mention **of** 'orbital' or 'sub-shell cancels 'shell mark' Each marking point for Al is independent*

QoWC: links together two pieces of information correctly within two of the sections below:
1. General trend across period
2. Be to B
Successive ionisation energies✓

[13]

10. High boiling point **or** difficult to break linked to strong bonds in the right context within Li **or** C ✓ 1

Li conducts by delocalised/free/mobile electrons ✓ structure: giant ✓metallic ✓ 3

or '+ ions with a sea of electrons' for giant mark

C conducts by delocalised/free/mobile electrons ✓ structure: giant ✓covalent with layers ✓ 4

N No mobile charge carriers/electrons/ions to conduct electricity ✓

simple molecular structure/made of N_2 molecules✓

low boiling point **or** easily broken due to intermolecular forces/ van der Waals' forces ✓ 3

QWC: At least 2 complete sentences in which the meaning is clear. ✓ 1

[12]

11. (i) O ✓ 1

(ii) AI ✓ 1

(iii) P ✓ 1

(iv) C/Si ✓ 1

(v) N/P ✓ 1

(vi) Mg ✓ 1

(vii) Na ✓ 1

(viii) Si ✓ 1

[8]

12. (i) Energy change when each atom in 1 mole ✓ of gaseous atoms ✓ loses an electron ✓ (to form 1 mole of gaseous 1+ ions). 3

(ii) increasing nuclear charge/number of protons ✓ electrons experience greater attraction or *pull* / atomic radius decreases / electrons added to same shell /same or similar shielding ✓ 2

(iii) In B, electron being removed is at a higher energy / In Be, electron being removed is at a lower energy ✓

An s electron is lost in Be AND a p electron is lost in B ✓ 2

[7]

13. (i) First ✓ ionisation (energy) ✓ 2

$Ra(g) \rightarrow Ra^{+}(g) + e^{-}$ ✓✓
1 mark for equation
1 mark for state symbols
'–' not required on 'e' 2

(ii) atomic radii of Ra > atomic radii of Ca/
Ra has electrons in shell further from nucleus than Ca/
Ra has more shells ✓

Ra has **more** shielding than Ca ✓
: '***more***' is essential

Ra electron held less tightly/less attraction on electron ✓ 3

[7]

14. N has less protons than O (ora) ✓
electrons are in same shell
/have same or similar shielding ✓
weaker nuclear attraction in N (ora) ✓
shell drawn in less by nuclear charge in N (ora) ✓

watch for distinction between nuclear **attraction** and nuclear **charge** in candidates' scripts.

QoWC: links together two statements in at least two of the sections (a)(ii), (b) and (c) ✓

[4]

15. (a) Energy change when each atom in 1 mole ✓

of gaseous atoms ✓ 3

loses an electron ✓ (to form 1 mole of gaseous 1+ ions).

(b) increasing nuclear charge/number of protons ✓

electrons experience greater attraction or *pull*/atomic radius decreases/electrons added to same shell/same or similar shielding ✓ 2

[5]

16. (From 2 →10 →18 / down group)

1st ionisation energies decrease/easier to remove electrons ✓
electron is further from nucleus/ atomic radius increases/

electron in a different shell/ atoms increase in size ✓
*(**not** sub-shell or orbital)*

electron experiences **more** shielding ✓
*(**more** is essential here)*

distance and shielding outweigh the increased nuclear charge ✓
NOT: attraction/pull; effective nuclear charge

[4]