

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) | Al (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)

3

nuclear attraction increases (1)

(ii) $\text{Na}^{2+}(\text{g}) \rightarrow \text{Na}^{3+}(\text{g}) + \text{e}^-$: 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^+ ✓

(ignore electrons: any mention of 'neutrons' is wrong)

1

(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 ✓

attraction increases/pull increases ✓

.....ORA

3

(iv) smaller ✓

shell has been lost/less shielding/less electron

repulsion/proton : electron ratio larger ✓

mark separately

2

[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 $\rightarrow$ 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 $\rightarrow$ 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 ✓ or '+ ions with a sea of electrons' for giant mark	3	
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) Al ✓	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 <i>pull</i> / 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
- $\text{Ra(g)} \rightarrow \text{Ra}^+(\text{g}) + \text{e}^-$ ✓✓
- 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]